WHO TURNS THE WHEEL?

Proceedings of a Workshop on the
Science Education of Women in Canada

Sponsored by the Science and Education
Committee of the Science Council of Canada

Prepared by Janet Ferguson

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FOREWORD

These workshop proceedings have been prepared in the context of a study of Canadian science education being undertaken by the Science and Education Committee of the Science Council of Canada. The study, which began in the spring of 1980, has three overall aims:

- to establish a documented basis for describing the present purposes and general characteristics of science teaching in Canadian schools;
- to conduct an historical analysis of science education in Canada;
- to stimulate active deliberation concerning future options for science education in Canada.

In February 1980, after the very poor participation of girls in school science was brought to the attention of the Committee, a workshop was held, and these proceedings resulted. The information presented at the workshop also prompted the Committee to publish a Statement of Concern, calling attention to the serious consequences of the low numbers of girls studying science.

The tasks of coordinating the workshop and preparing these proceedings have been undertaken capably and conscientiously by Janet Ferguson, a member of Council's research staff. For its part, the Committee takes pleasure in publishing these proceedings in the hope that it will stimulate both discussion and action.

James M. Gilmour
Director of Research
Science Council of Canada

INTRODUCTION

Why are there so few Canadian women in science? This question prompted the Science and Education Committee of the Science Council of Canada to seek a better understanding of the relationship between girls and science as part of its ongoing study of science education in Canadian schools. The difference in the degrees of participation of men and women in the scientific professions in Canada is enormous. For example, in 1976 the percentage of women doctoral candidates who received degrees in engineering, mathematics, and the physical sciences was too small to be measurable.[1] Even in biology, where traditionally women have figured more prominently, almost no women were receiving doctorates. Inevitably, the number of women teaching and doing research in these fields in universities and in industry is also extremely small. A slightly less dramatic version of the same situation exists at the level of Master's and Bachelor's degrees; this is similarly reflected in a paucity of women teaching science in high schools.

What are the forces that pull girls away from science? Do they differ in essence, or in strength only, from the forces that steer them away from active involvement in other areas of the working world? How can it be that, despite all the changes in opportunities for and achievements by women today, they still do not do science?

The tendency for girls to opt out of science courses may have profound economic and political consequences in a world where the impact of science and technology is becoming increasingly significant. Technology pervades every area of our daily lives, from the food we eat, to the cars we drive, the TV we watch, the machines we use for cooking and washing, even to the manner in which we determine who shall be the next generation, and when and how they will be born. We have, rather suddenly, become capable of controlling and altering parts of our lives previously outside human influence. As a result, individuals lacking the necessary knowledge and skills will become more and more dependent on a scientific and technological elite for everything from simple repairs to major life decisions. While no individual can be expert in all areas, the ability to use our new capabilities with consideration and caution, rather than fear or ignorance, and our ability to obtain maximum profit from them will be determined, at least in part, by our ability to understand the language of science and technology.

Women must be able to participate in directing technological innovation and determining the speed and manner in which new developments are introduced into society. They will need to be well informed and well represented in the professional scientific community.

But there are other important reasons for women to increase their scientific and technical skills as well. One way or another, technology will continue to affect the labour market at many levels. From a practical point of view it is evident that girls who do not acquire the basic elements of mathematics and physics will not be eligible for admission to science and technology training programs in postsecondary institutions. These are the programs that produce skilled personnel for the expanding job market resulting from technological innovation. As a result, women are finding that they are unable to take advantage of the opportunities presently developing in this area. They lack not only the skills to do the jobs, but also the qualifications required for admission to the required training programs.

The traumatic impact of microelectronics on traditionally female jobs in banks, as telephone operators, and as clerical staff has been graphically documented in a report by Heather Menzies recently released by the Canadian Institute for Research in Public Policy, entitled Women and the Chip.[2] Estimates of possible unemployment rates among women in the clerical sector range from a level of 10 per cent in 1985, to a high of 35 per cent by 1990. Realization of these figures depends on the speed with which the technology is introduced, the rate of industrial expansion and the growth of the unskilled female work force. Because technological innovation and industrial expansion are generally perceived as beneficial to the economy, it is the growth of the unskilled female labour force that must be altered if these levels of unemployment are to be avoided. Menzies' study indicates that few of the employees presently being displaced are qualified to move up to the more skilled, managerial, and semimanagerial positions that are being created as a result of the new technology.

The potential impact on the Canadian economy of female unemployment is evident in the observation, quoted by Menzies, that the number of Canadian families living below the poverty line would increase by 50 per cent if women were not working. The National Council on Welfare has reported that half the families where both parents work have a combined income of less that $15 000 per annum.[3] In other words, many families will suffer if unemployment among women is allowed to rise to these levels. Education to upgrade the general level of technical and scientific skills among women is therefore essential. Girls in high school must be made aware of the changes occurring in the workplace and must be encouraged to prepare themselves for more technologically oriented jobs.

Studies in other countries have suggested that the separation of girls from science starts early in life, and that the gap becomes progressively more obvious at each succeeding stage of the education process. The Science and Education Committee of the Science Council of

Canada decided to investigate the situation in Canadian schools by sponsoring a one-day workshop, in February 1981, in Ottawa. The workshop addressed the following questions:

- To what extent are girls in Canadian schools avoiding the study of science?
- What forces are presently acting to generate this problem?
- What can the education system do to counteract these forces?

A keynote address was delivered by Dr. Rose Sheinin of the Department of Microbiology and Parasitology at the University of Toronto. She discussed the lack of involvement of women in science, both at school and in the work force in the light of the limited expectations society holds for women in the working world. This paper provided a background against which each of the subsequent pieces of the problem could be examined.

Papers presented in the morning session examined the statistical data that document the extent of the problem in Canada, and two areas of theoretical work that offer explanations of why girls do not study science. In the afternoon session, the roles of educators and policy makers, as contributors to both the problem and solutions, were discussed. Four panelists presented their own practical perspectives, and concluding remarks were provided by Dr. Louise Marcil-Lacoste, of the Department of Philosophy at the Université de Montréal, and a member of the Science and Education Committee.

While these Proceedings are based on the presented papers, most chapters have been expanded to include additional information or edited to facilitate the continuity of the whole.

In addition to the papers, the address delivered by the Honourable Lynn Verge, Minister of Education for Newfoundland and Labrador, and President of the Council of Ministers of Education is reproduced in full in Appendix A.

The title of this publication is derived from an observation by Dr. Sheinin in her opening address. She asked why the majority of Canadian girls grow up expecting to repeat the domestic life cycle that their mothers and grandmothers experienced. Many girls still seem to believe that achievement in the working world, particularly the world of science, is incompatible with their feminine roles as mates and mothers. Birth and schooling lead inexorably and exclusively to marriage, children, and old age, and so the wheel of fortune rolls along. Yet the same wheel leads many boys to scientific careers in industry, government, and university. If we really want to change the position of women in science, Dr. Sheinin pointed out, we need to ask, "Who turns the Wheel?"

I. Women in Science... and Why Not/Nought?

Rose Sheinin
University of Toronto

The subject I would like to address in today's workshop is, "Women in science ... why not?" It is now 47 years since the sexual social revolution was launched with the introduction of oral contraceptive pills. It is now 40 years since the women's liberation movement was revived by Simone de Beauvoir in her book The Second Sex. And it is 7 years since International Women's Year. I would dearly love therefore, to be able to declare in the swinging advertising sort of way, "You've come a long way baby! - Women in science ... why not!"

But unfortunately we are not in a position to do so because the science scene, in academia, in industry, and in government is still largely populated by men. In fact, if you go to some of the subdisciplines of science you find that there are no women at all and the question you are forced to ask then is "Women in science ... why nought?" The simple answer is that women are not graduating from university science faculties, engineering faculties or polytechnical institutes because they are not entering them. This situation probably exists because they do not receive adequate science training in high school and this in turn would seem to be the result of inadequate preparation and encouragement in science at the primary school level.

Why should this be the case in a country which prides itself on providing first-class education for all its citizens, a country with a bill of rights providing equality of opportunity for all its citizens? We all assume this equality of opportunity extends to education, jobs and a rich cultural life, and indeed it does. The law actually guarantees us these rights. But to have a fighting chance to achieve them you must start by asking that they be fulfilled. Here lies the crux of the problem. A majority of

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Note: Papers and quotations from papers appear single spaced.

young women have not chosen to take advantage of their "guaranteed" rights by pursuing careers in the traditionally male enclaves of science, engineering and technology (hereafter referred to as SET).

We who deal in facts usually try to do our jobs with precision. In a rational age, and in a rational society, we go about collecting the numbers which must be provided for the bureaucrats and others at all levels who make decisions about our lives. While England and the US have extensive data available pertaining to numbers of women in SET, Canada does not. Two recently formed groups, the Canadian Association for Women in Science in Canada, and the Committee on Equal Opportunity for Women in Biochemistry, are planning to establish registries of women in science and in biochemistry respectively. Hopefully the appropriate arms of government will be interested in helping to establish the necessary data base.

However, no one really needs a statistical analysis to tell us what we already know. And we who deal in facts, I think, have been doing the wrong thing in the wrong place at the wrong time. Our approach has not been unlike that of the inebriate who insists on looking for a lost watch under the lamppost where the light is, rather than the dark, murky, difficult place where it was actually lost. We are focusing our attention under the lamppost when we concentrate on gathering facts to prove what we already know is true: there are very few women in science, engineering and technology in Canada. Looking for the reasons for this situation takes us into a much darker, more difficult area.

Where should we be looking to discover why there are no girls in SET teaching and training streams? I believe we should be focusing on those who provide the earliest and most profound cultural, social and behavioural imprint on our Canadian children; we should be examining the role models provided for our baby girls and the cultural and economic expectations that Canadian society has for them. Our national and international science journals are replete with data that document what every mother, father, aunt, uncle, grandparent, priest, rabbi, whore, indeed what every human being in every society knows instinctively: the cultural, ethical and moral values that determine our collective societal behaviour are learned at the mother's breast and the father's lap. It is this cultural, ethical and moral imprint that determines our collective societal behaviour. It is this collective cultural and moral philosophy that determines, almost at birth, that our daughters do not become interested in SET, and ensures that this behaviour pattern is reinforced in primary and secondary schools by teachers, by career counselors, by principals, and by departments of education. It is this philosophy that ensures our young women do not enter the portals of SET faculties in tertiary institutions. Therefore it is this philosophy that gives us the reality of very few women in the adult working world of SET.

What is this cultural, social, ethical and economic imprint that Canadian society lays upon its young people so that the two sexes go their separate professional ways as adults? It can be described as the German concept of Kinder, Kuche, Kirche (children, kitchen and church). In our society the same attitude is more crudely expressed: women should be barefoot, pregnant and in the kitchen. Perhaps the North American version is more honest, as it spells out the cultural and economic sexism of our society that is manifested as overt and ubiquitous male chauvinism. To be barefoot implies women should be economically non viable. To be barefoot and pregnant suggests a woman's life should be subservient to her biological function relative to the survival of the species and of the society. That women should be in the kitchen implies they should be subservient to the total needs of society in that they shall nurture us all.

The collective philosophy of a society is often reflected in its classical and popular art. Classical art often reveals a view of woman as a Madonna, as a loving, caring mother figure and sometimes as the vital creative force of mankind. The devastating effect of poverty on mothers and children is only occasionally portrayed. Rarely are women depicted in the workplace in other than such typically domestic roles as shopping and washing. Women are never portrayed as scientists, engineers, or authority figures unless they are monarchs and goddesses. Though they are often seen as teachers, women are never depicted on school boards. In the socialist-realist paintings of countries such as the Soviet Union women are presented in nontraditional workroles as tractor drivers or engineers but, once again, rarely as authority figures. The social framework within which our children are raised reflects its values in its arts, portraying women as mothers, as nurturing people who rarely work outside the home (except in Russia), as people who never occupy positions of authority or enjoy careers in science or technology.

How do we project our social values? We all recognize the cycle in which men and women marry and have children. These children grow up, go to school, acquire varying degrees of education and eventually enter the work force. Then they become the mothers and fathers of the next generation, and so the wheel of fortune turns and turns. But who turns the wheel, and in what direction?

I believe the home environment plays the most crucial role in education and child-rearing. In the home the first major educational imprint is made, and superimposed on this is society's impact. Society in the guise of all its institutions: the family, the schools and churches and the workplace, turns the wheel, but its direction is determined by the underlying cultural philosophy most strongly imprinted in the home. The message being delivered to our children at home and in the street is that women are not wanted in our work force. The economic sexism of our society is evident in our failure to provide role models of women sharing the workplace with men. Why should this be so?

Cartoon artists often exaggerate the unarticulated assumptions of a society to make them more obvious. One such cartoon shows a little girl wearing an enormous pair of shoes, as little girls will do. Her shoes are exactly the same as her mother's bigger shoes and these are the same as the great big shoes of the grandmother. Mother and Granny are drinking afternoon tea. Another cartoon granny, in stereotypical curlers and housecoat, tells her granddaughter that the cake she has baked is delicious and she will make some man a fine roommate someday. In the face of a major change in social custom, our daughters' role models have remained the same, and society's expectations for her future are essentially unaltered.

In another cartoon we see a male executive sitting at his desk. Behind him on the wall hang a seemingly endless succession of portraits of executives who are clearly his ancestors. The man is identical in pose, attitude and appearance to his father, grandfather, great-grandfather and so on. The major discrepancy between the role models these cartoons portray for girls and boys is obvious.

Children see other role models outside the home. While most nuclear and extended families provide equal numbers of models who are women and men, the women are very seldom scientists, engineers, or technologists. In elementary schools, women teachers still predominate and at this level some women teach some science. At the junior and senior high school levels, however, the ratio of men to women teaching science is ridiculously lopsided, and becomes more so at the postsecondary level in universities, community colleges, and polytechnical institutes.

There appear to be no women who stand out as spokespersons for women in SET industry. Government science laboratories have few, if any women in managerial positions. Canadian girls are not being provided with role models in science, engineering and technology. The message from the situation is clear. There is no room, no desire and no need for women scientists, and the implicit warning is that if you become one you won't be able to get a job. This is the major message of the cultural and economic sexism which permeates every aspect of our Canadian society. Delivered first in the home by parents and other members of the nuclear and extended family, it is reinforced in the street and delivered day in and day out in our educational institutions for up to twenty-one years. This problem must be addressed if we are to change the pattern of science education for girls.

Unfortunately my reading of history suggests that change in any form of prejudice is difficult. Cultural modification moves at a glacial speed, and to effect any rapid change requires affirmative action with appropriate positive and negative reinforcement. The steps that should be taken to effect cultural change are so wide-reaching they are difficult to define and achieve. Legislation equivalent to the Equal Rights Amendment and the legislation guaranteeing equal pay for work of equal value that is currently being fought for in several provinces can be used to deal with economic sexism.

Educational sexism is easy to see if we will open our eyes and look. To deal with this problem so that our Canadian girls can emerge with a real and equal share in Canada's future will require once again, affirmative action. These measures must be defined in direct legislation analogous to the ERA, and they must be embodied in the charter of rights presently being designed as attempts are made to patriate the Canadian constitution.

Six areas that must be addressed with affirmative action measures are set out in Table 1.

Table 1 - Areas That Affirmative Action Measures Must Address

1. Modify cultural stereotypes in the home;
2. Change the ratio of females/males teaching math, physics, chemistry and engineering at school;
3. Provide separate but equal science classes for girls;
4. Change female/male ratio in higher education;
5. Change female/male ratio in professional societies;
6. Change hiring patterns of women by industry.

Item 1, modifying cultural stereotypes in the home, will be the most difficult. Items 2, 4, 5 and 6 need no explanation. I would like to raise the idea (item 3) that separate but equal teaching be provided for girls in mathematics and science. This suggestion is based on data that indicate girls who are taught SET subjects in all-girls schools or girls classes succeed in these areas much more frequently than girls in coeducational classes.

If strategies and tactics can be defined that successfully achieve these goals we will ensure that our girls and boys become women and men who will be able to deal with, and benefit maximally from the technologically-oriented, science-based lifestyle towards which our world is relentlessly moving.

I would like to close with a quotation from an article on education for girls in Britain. "Many adults who influence childrens' upbringing seek to preserve their own mental and emotional equilibrium by maintaining traditional attitudes, and it is this factor which most seriously hinders the progress of equal opportunity for girls." Our own attitudes must be changed in order to provide a future for our girls anywhere, and particularly in science, engineering and technology.

II. Is There A Problem?

Enrolment and Achievement Patterns Among Girls in High School Science in Canada

Based on a presentation by
Joan Scott
Memorial University
Newfoundland

Dr. Sheinin emphasized in her opening address that the absence of women from the professional scientific world was an obvious and inevitable result of the fact that very few girls study science at university or in high school. While this situation has been under study in other countries for several years, concern about the number of girls studying science in Canadian high schools has not been widespread. The dimensions of the problem in Canada ought to be documented. Joan Scott, from Memorial University, has gathered statistics relating gender to enrolment and achievement in high school science in Canada and presented some of that information to the workshop.

Enrolment in Science Courses

Provincial ministries and departments of education were asked to provide statistics, analyzed by gender, of enrolment in high school science and mathematics courses. A summary of enrolment figures in physics, chemistry and biology in four provinces (British Columbia, Ontario, New Brunswick, Newfoundland) is presented in Table 1, while other data from Newfoundland, New Brunswick, Ontario, Nova Scotia and British Columbia are contained in Tables 2 to 6. (Tables presenting the data upon which the following conclusions are based have been grouped together at the end of this chapter.)

Physics

The percentage of girls in each grade who were enrolled in physics varied from a low of 8.6 per cent in Newfoundland to a high of 25.2 per cent in New Brunswick (Tables 2 and 3). In each province, the figures for boys are two to three times as high as those for girls, varying from 24.8 per cent in Newfoundland to 40.3 per cent in New Brunswick. Nova Scotia reported 1440 boys and 787 girls studying physics in grade twelve in 1979-80 (Table 4).

An Ottawa Board of Education study of sex differences in high school course choice and achievement found that in a sample of grade eleven students, 76 per cent of the girls and 40 per cent of the boys were not studying any physics or chemistry (Figure 1). In most schools in Ontario, physics is offered in grade eleven and chemistry in grade twelve, so the figures for grade eleven represent primarily students taking physics.[1]

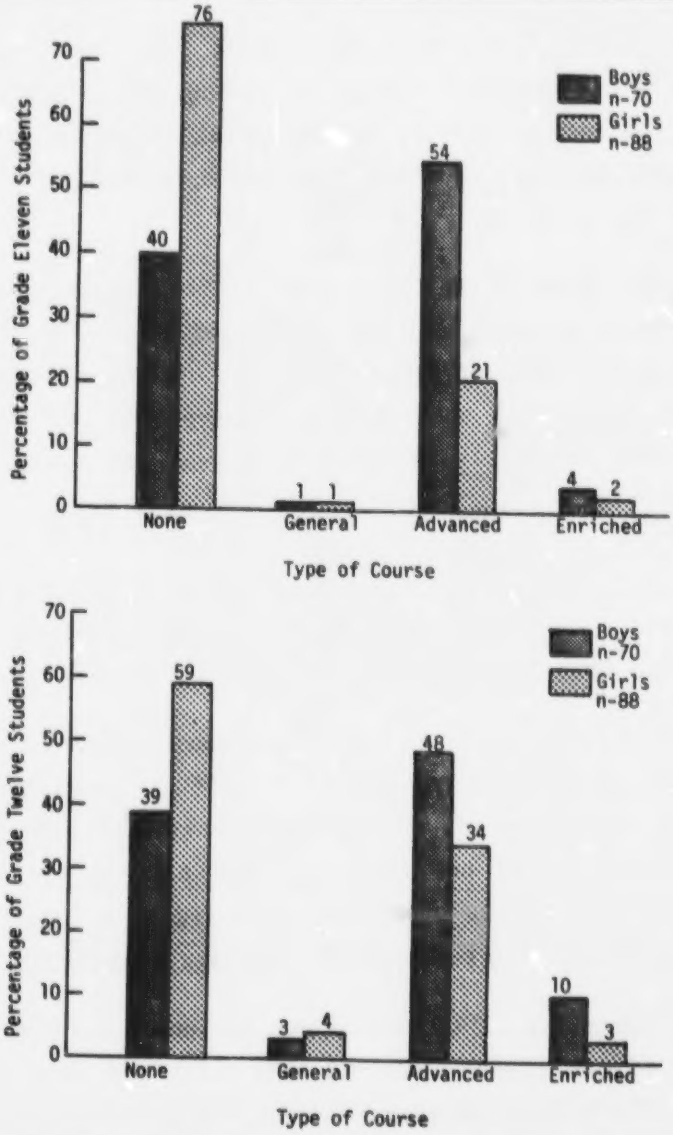
Chemistry

A larger percentage of girls appear to study chemistry than physics. New Brunswick and Nova Scotia reported that more girls than boys studied chemistry, though the difference was small (Tables 3 and 4). In Newfoundland, British Columbia and Ontario a considerably larger number of boys than girls took chemistry, but the difference was smaller than that for physics (Tables 1, 2, 5 and 6).

According to the Board of Education study, 58 per cent of the girls and 39 per cent of the boys in the Ottawa study were not taking chemistry or physics in grade twelve.[2]

It is interesting that the unusually high enrolment of females in chemistry in New Brunswick resulted from the higher number of francophone females studying chemistry than francophone males. There were fewer anglophone females in chemistry than anglophone males. It should be noted, however, that total enrolment in New Brunswick was based on

Figure 1 - Physics and Chemistry Course Choices from Grade Eleven to Grade Twelve



Source: M. Suderman, Sex Differences in High School Course Choice and Achievement: Cause for Concern?, Ottawa Board of Education, Ottawa, Ontario, 1979.

enrolment in either français or English as a first language, and this may bias the results.*

Biology

In the provinces included here, more girls than boys study biology. This may reflect a genuine interest in biology among girls, or it may reflect the tendency of schools to require at least one science course for graduation. Biology is often perceived by students to be the least difficult of the sciences.

The Ottawa study established that in grade eleven in Ottawa, a larger percentage of girls (31 per cent) than boys (27 per cent) were studying advanced levels of general science, biology and geology, which were grouped together in that study.[3] However, 56 per cent of girls and 53 per cent of boys were not studying any of these subjects in grade eleven (Figure 2).

Mathematics

In Ontario the number of girls studying pure mathematics in grade 13 (1979) was less than two-thirds of the number of boys.

The percentage of girls in the Ottawa sample studying advanced and enriched level mathematics had dropped from 56 per cent in grade ten to 35 per cent in grade twelve, while the percentage of boys dropped only from 75 per cent to 67 per cent over the same period.[4] By grade twelve, 26 per cent of the girls were studying no mathematics at all, as compared with only 4.0 per cent of the boys, (Figure 3).

In New Brunswick, 39.1 per cent of grade twelve girls were enrolled in a math course compared with 53.5 per cent of the boys (Table 3). These figures appear to be rather low for both sexes. Examination of the data in Table 3 reveals that only 35.7 per cent of

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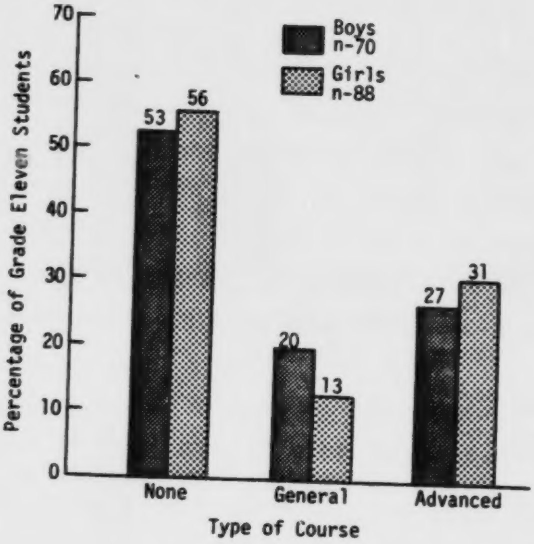
* "Français" refers to the courses in french literature and grammar that are taught to francophone students.

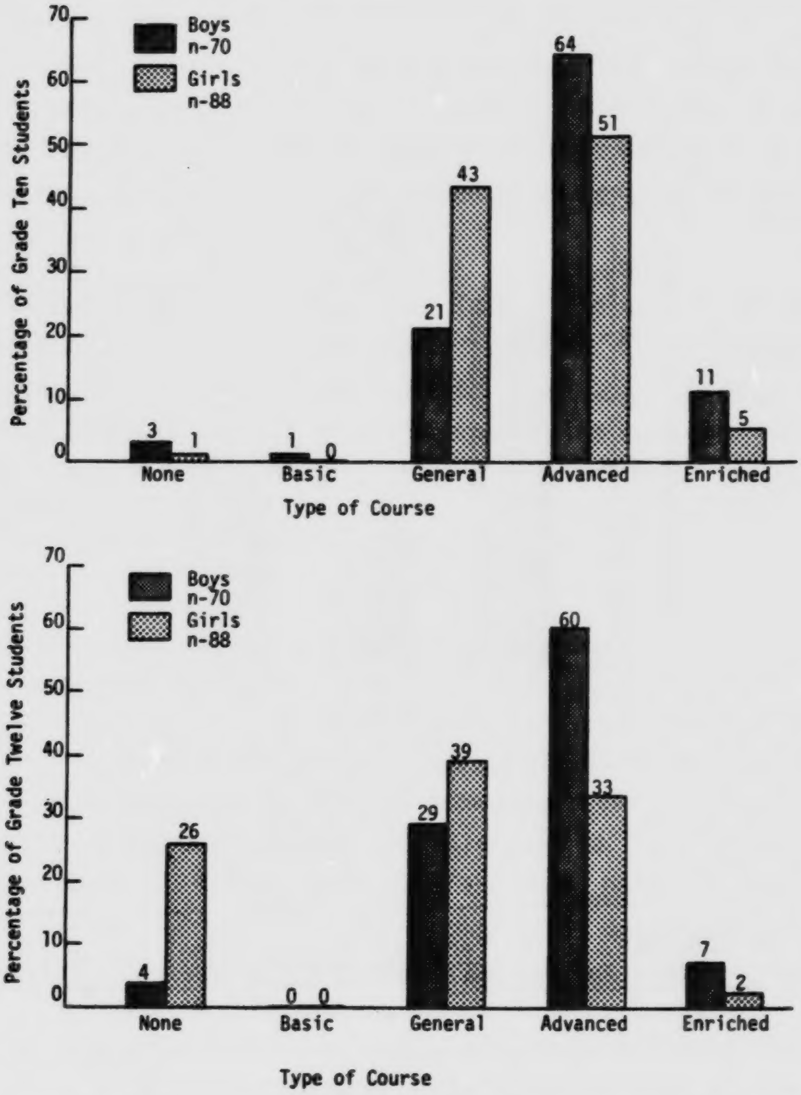
Figure 2 - General Science, Biology and Geology Course Choices in Grade Eleven



Source: M. Suderman, Sex Differences in High School Course Choice and Achievement: Cause for Concern?, Ottawa Board of Education, Ottawa, Ontario, 1979.

francophone boys and 32.8 per cent of francophone girls were studying math of any kind. While the difference in male/female enrolment is considerably smaller here than in Ontario (Table 6), both figures appear low enough to suggest that other environmental factors may be important.

Figure 3 - Mathematics Course Choices in Grades Ten and Twelve



Source: M. Suderman, Sex Differences in High School Course Choice and Achievement: Cause for Concern?, Ottawa Board of Education, Ottawa, Ontario, 1979.

Summary of the Enrolment Data

On the basis of the data, we can conclude that considerably fewer girls than boys are studying senior physics and math. Twenty-six per cent of the senior girls in the Ottawa sample were studying no math in grade twelve, and 59 per cent appeared to be studying no physics or chemistry at that level (Figures 1 and 3). The percentage of girls studying chemistry seems to be closer to the percentage of boys, and more girls than boys were taking biology in all reporting provinces.

These observations are in accord with patterns of science enrolment in the UK reported by Kelly.[5] Enrolment figures for the class of fifth form students in Britain show that the percentage of boys taking physics (52 per cent) was three times the percentage of girls (17 per cent). Boys outnumbered girls in chemistry by a smaller margin (35 per cent versus 22 per cent), while more girls than boys study biology (52 per cent girls versus 31 per cent boys).

Achievement in Science

> "In Ontario, 94.7 per cent of girls passed physics as compared with 90.7 per cent of boys (Table 6). The data from Nova Scotia give girls a higher mean score than the boys (Table 4).
>
> "In chemistry the picture is similar. In Ontario, 95.5 per cent of girls passed compared with 92.6 per cent of boys (Table 6).
>
> "In biology, Newfoundland and Ontario girls have the higher pass rates (Tables 2 and 6)."

In Newfoundland, the percentage of boys passing and/or scoring over 80 per cent in both physics and chemistry was larger than the percentage of girls doing so. On the other hand, more girls passed and scored over 80 per cent in matriculation algebra (Table 2).

Interpretation of the data is complicated by the fact that the small percentage of girls who enrol in physics and chemistry may also represent the most academically able group. The larger percentage of boys is likely to include a significant proportion of individuals of more average ability. Nevertheless, as Scott pointed out, the achievement figures do suggest that girls are capable of doing very well in physics, chemistry, biology and mathematics.

A study by Hobbs and Erickson examined students' understanding of concepts, process skills, applications, safety, scientific literacy, and attitudes in grades four, eight and twelve.[6] Scott reported that:

> "In all grades boys outscored girls in understanding concepts in physics and chemistry. In biology the sexes were equal on average, but girls were ahead of the boys on some concepts, while boys were ahead on others. This divergence was quite evident as early as grade four.
>
> "There were no significant sex differences on other variables with the exception of the following attitude measures:
>
> > 1) About twice as many boys (60 per cent) as girls (29 per cent) reported trying to find out how mechanical things around the house work, quite frequently or very frequently.
> >
> > 2) More boys (35 per cent) than girls (20 per cent) reported trying to find out, at least a few times, how industries apply science.
> >
> > 3) More girls (73 per cent) than boys (51 per cent) indicated they had never successfully designed and carried out their own experiment.
> >
> > 4) More girls (43 per cent) than boys (30 per cent) indicated that they had never voluntarily carried out an experiment from sets of instructions."[7]

These results are of interest in the light of the suggestion by Dr. Fischer (see Chapter IV) that girls are missing out on early experiences of science that may be essential to the subsequent development of science concepts. The negative feedback loop discussed there appears to have begun before grade four, when science concepts and attitudes can already be seen to be differentially developed.

Limitations of the Data

The assessment of the data relating enrolment and achievement in science courses to gender is complicated by the diversity and incompleteness of the available statistics.

> "While all provinces were contacted for their most recent enrolment and achievement data in the last years of high school, divided by sex, only a few were able to respond with the appropriate statistics. British Columbia, Ontario, New Brunswick, and Newfoundland supplied some relevant data. Manitoba was unable to provide information divided on the basis of sex, and the data from Nova Scotia lack total enrolment figures.
>
> "As total enrolment figures were unavailable in some cases, an estimate of the total number of girls or boys in a particular grade was based on largest subject enrolment. This was usually found when either English or français was a first language."

It is evident that errors may occur when not all students in a grade are enrolled in English or français, or if some of the students enrolled are actually in a different grade. This happens when students take courses ahead of or behind their official, recorded grade level.

Regional variations on an intraprovincial basis were not examined except in the case of Ottawa, where a specific study of the relationships between course choice, achievement and gender has been carried out. Comparison of data from different provinces and schools is complicated by the possibility of regional variations.

> "The courses examined are not always strictly equivalent. Two courses with the same name may have different content, vary in length, and differ in the method of evaluation. The age of the students sampled varies as well, as some provinces have only eleven years of schooling, while most have twelve and Ontario currently has thirteen years."

The picture that develops may be open to some criticism and misinterpretation. It is clear that more uniform methods of record keeping would be a valuable aid in many education studies and this process could be facilitated by the use of computer technology.

The Definition of Science

Several participants at the workshop expressed concern over the apparently narrow range of science subjects examined in this paper. However, it should be understood that interest in the participation of girls in high school science has originated from a concern over the relative absence of women from the science professions, and the impetus for the initial examination of the subject grew out of that concern. As a result, the statistics that have been collected to describe the enrolment of girls in high school science reflect this concern. Attention has been focused on female enrolment in physics, chemistry, biology, and mathematics as these are the subjects traditionally required for admission to postsecondary science programs.

It is becoming increasingly evident, however, that the study of science is of great importance in the lives and careers of women who are not interested in postsecondary education. An increasing number of science- and math-based courses, such as environmental studies and agriculture, are being offered in Canadian schools and these subjects can play an important role in improving scientific literacy, awareness and skills. They may also prove more attractive to girls. At present however, these courses are not generally accepted for admission to such fields as physics, electronics, computer programing, or engineering. In addition, their nature and availability varies widely across the country. While a collection of comparative statistics would undoubtedly be useful, it would also be an extensive procedure and beyond the scope of this workshop. Our functional definition of science was thus limited to the rather narrow area of physics, chemistry, biology and (where data were provided), mathematics.

Comparison with International Data

Kelly has discussed an extensive international study of sex differences in science achievement in fourteen countries.[8] The tests and methodology used in the study are outlined in Kelly and the results provide several interesting insights.[9] Within each country, 14-year-old boys performed better on standardized achievement tests than 14-year-old girls in all science subject areas. However, comparisons of achievement between countries reveal that Hungarian girls had better scores in biology than boys in any other country except Hungary, and better scores in chemistry than any but Japanese and Hungarian boys. Japanese girls had higher scores in physics than boys in ten of the countries studied (including Britain and the US).

These observations, and the consistently higher scores of students in Hungary and Japan in all the sciences suggest that cultural and environmental factors may be as important as gender in determining science achievement.

Tertiary Education Enrolment in Canada

Though the major concern of this workshop was the participation of girls in high school science, it is interesting to examine the pattern of female involvement at the postsecondary level, at least in areas influenced by high school science achievement.

Table 7 presents a summary of female participation in science, medicine and engineering in all ten provinces and in Canada as a whole in 1978-79. The data are derived from Statistics Canada.[10] They indicate that the proportion of women in engineering was less than 10 per cent on a national basis. Approximately one-third of the medical student population was female. This figure represents a significant improvement over the situation in 1970 when fewer than one-fifth of medical students in Canada were women.[11]

The overall percentage of women in science subjects was 37.8 per cent in 1978-79, but this figure must be considered in the light of the known tendency for a disproportionately large number of women to study biology. Enrolment in specific fields of science in 1978 is presented in Table 8. Women made up 46 per cent of the students in biological sciences, 26 per cent in the physical sciences, and 11 per cent of engineering undergraduates. It must be assumed that the category "all fields" includes non-science areas because women are said to comprise 50 per cent of the total enrolment, a figure which is larger than any of the separate science figures.

Statistics for female enrolment in science programs at the Université du Québec in Montréal were provided by Dr. I. Lasvergnas-Grémy and Dr. M. Demers, workshop participants. These figures are presented in Tables 9 and 10 and are consistent with the trend towards a concentration of women in biological sciences observed in other regions. It is a notable fact that the percentage of women students at the Bachelor's and Master's levels increased from 16 per cent to 29 per cent in seven years.

The Teaching Profession

Scott presented data prepared in Newfoundland for the Minister's Committee on the Education of Girls that show:

> "In elementary schools there is a woman teacher for every 12 girls, but in high schools the ratio is 1:75. This situation is not limited to Newfoundland. The percentage of women teachers at that level across Canada is 31.5 per cent and declining. Physics is particularly likely to be taught by a man. The ratio of men to women physics teachers is 14:1 in one province."

As noted by Drs. Lasvergnas-Grémy and Demers, the situation with regard to the number of women teaching science at the university level is even more alarming.

> "In 1977, women comprised only 13 per cent of the science faculty at the UQAM (Université du Québec à Montréal); but the fact that this is a comprehensive figure for all departments conceals certain very important differences between departments. While 27 per cent of the chemistry faculty, and 16 per cent of the biology faculty are women, there are no women in the Departments of Physics and Earth Sciences."[12]

Some progress has been made over the past 15 years. The percentage of women professors in Life Sciences and Exact Sciences increased from 1.3 per cent in 1960 to 4.5 per cent in 1975, in all francophone universities, with the exception of the Université du Québec, but these percentages are still exceedingly small.[13]

Scott suggested the predominance of male teachers in science areas in schools and universities may cause girls to perceive women as a minority or "token" group in science. She went on to point out that:

> "Marion Lowe, professor of Chemistry and Women's Studies at the University of Boston has referred to a phenomenon of "depressed aspirations." It is a recognized, realistic response to being treated as a token or as a minority. This behaviour is in no way a prerogative of girls and women, but is seen in men under similar circumstances."

This suggests girls do not aspire to scientific and technical careers because they perceive that women form a small minority in these fields, and this disparity leads them to assume that girls would be inappropriate and unwelcome participants. Individual women who do participate in science may be viewed as eccentric and thought of as the "token" exceptions that prove the rule.

Girls who are vastly outnumbered by boys in science classes may develop similar feelings about science classes.

> "There is a body of literature showing that girls in coeducational schools are both more likely to be offered physics and less likely to take it than in single sex schools.[14] The balance of the sexes in the classroom environment may for some girls be a major reason for the state of their aspirations in physical sciences. It is also suggested by psychologists that differences in the developmental sequences of girls and boys may indicate that good single-sex schools offer an optimum environment for learning.[15]
>
> "Until there is a reasonable balance of the sexes among ministers, in provincial departments, among trustees, school administrators, school science consultants and teachers, the question of women's needs and aspirations as they relate to school science cannot be addressed."

While this long-term aim is certainly desirable, the need to improve the participation of girls in high school science is too pressing to await its attainment.

Conclusions

The data presented by Scott represent clear reasons to be concerned about the participation of girls in certain high school sciences. Particular attention needs to be devoted to increasing the number of girls studying mathematics and physics. These subjects are the ones most frequently avoided by girls, but also the ones very often required for admission to postsecondary training programs at community colleges, universities and technical colleges. A basic level of competence in these subjects is a necessary condition for many jobs as well.

A brief reflection suggests that any involvement in science, beyond the most elementary, requires competence in physics, chemistry and mathematics. For example, the names of such subdisciplines of biology as biophysics, biochemistry and biostatistics reveal the extensive interaction among the sciences. Neurophysiology requires a fundamental understanding of the physics of electricity; muscle physiology revolves around concepts of force, tension and heat production; and genes are actually chemical molecules. By opting out of physics and mathematics early in school a student eliminates any possibility of being seriously involved in any branch of science.

Table 1 - Enrolment in Selected Science Subjects in Various Canadian Provinces

	Grade	12		13		12		11	
		BC (late 1970s)		Ontario 1979		NB 1979-80		Nfld. 1978-79	
		%	No.	%	No.	%	No.	%	No.
Physics	M	38.0	4 857	31.2	12 592	40.3	2 021	24.8	915
	F	17.2	2 324	11.3	4 557	25.2	1 364	8.6	336
Chemistry	M	41.6	5 326	32.8	13 216	33.8	1 693	17.0	627
	F	35.4	4 789	22.2	8 954	35.1	1 900	12.3	480
Biology	M	45.4	5 808	26.1	10 521	34.0	1 702	53.9	1 988
	F	57.0	7 713	34.2	13 814	45.8	2 482	75.3	2 940

Table 2 - Enrolment and Achievement of Newfoundland Grade 11 Students in Selected Science and Mathematics Subjects, by Sex

Subject		1973-74*		1976-77 †		1978-79 †		1973-74*			
		Enrolment		Enrolment		Enrolment		Passing		Over 80%	
		%	No.	%	No.	%	No.	%	No.	%	No.
Physics	M	14.5	485	21.2	742	24.8	915	62	297	13	64
	F	4.3	154	5.8	233	8.6	336	55	85	9	14
	Both	9.1	639								
Chemistry	M	9.0	303	13.6	476	17.0	627	51.8	157	8.2	25
	F	8.8	314	13.1	525	12.3	480	42.4	133	4.8	15
	Both	8.9	617								
Biology	M	37.6	1 261	49.2	1 722	53.9	1 988	65	812	11.1	140
	F	57.5	2 041	73.0	2 927	75.3	2 940	69	1 404	18.2	372
	Both	47.1	3 302								
‡ Matric Algebra	M	56.2	1 884	65.3	2 286	63.8	2 352	58.5	1 102	17.9	337
	F	62.9	2 232	76.6	3 072	70.9	2 768	68.3	1 725	20.2	450
	Both	58.7	4 116								
Hons. Math	M	-		5	175	11.3	417		-		-
	F	-		8	321	11.7	457		-		-
	Both										
Total in Grade 11	M	48.6	3 354	48.6	3 508	48.6	3 688				
	F	51.4	3 548	51.4	4 010	51.4	3 904				
	Both		6 902		7 518		7 592				

* From total students.

† Percentages from samples n = 300. Numbers are calculated from provincial total number of students in Grade 11. Percentage on each sex not available for 1977 and 1979, so percentages from 74 are used for these years.

‡ Single math subject taken by majority. It also shows greatest spread of marks.

Table 3 - Enrolment of Grade 12 New Brunswick Students in Selected Science and Mathematics Subjects, by Sex and Language Group, 1979-80

		Language Groups Combined		Francophones		Anglophones	
		No.	%	No.	%	No.	%
Physics	M	2 021	40.3	620	39.7	1 401	40.6
	F	1 364	25.2	399	24.9	965	25.3
	Both	3 385	32.5	1 019	32.2	2 366	32.6
Chemistry	M	1 693	33.8	421	27.0	1 272	36.9
	F	1 900	35.1	577	36.0	1 323	34.7
	Both	3 593	34.5	998	31.6	2 595	35.7
Biology	M	1 702	34.0	424	27.2	1 278	37
	F	2 482	45.8	811	50.7	1 671	43.8
	Both	4 184	40.1	1 235	39.1	2 949	40.6
*Total Grade 12 Math	M	2 680	53.5	558	35.7	2 122	61.5
	F	2 117	39.1	525	32.8	1 592	41.7
	Both	4 797	46.0	1 083	34.3	3 714	51.1
†Total in Grade 12	M	5 012	100	1 561	100	3 451	100
	F	5 416	100	1 601	100	3 815	100
	Both	10 428	100	3 162	100	7 266	100

* Total enrolled in all grade 12 math courses.

† In the absence of total enrolment figures, totals enrolled in français or English as a first language have been used and may be biased towards incorrectly increasing numbers of females slightly.

Table 4 - Enrolment of Nova Scotia Grade 12 Students in Selected Science Subjects, by Sex

Subject		Enrolment		Mean Scores	
		No.	%*	1979	1978
Physics	M	1 440		10.14	12.28
	F	787		12.04	10.25
	Both	2 227			
Chemistry	M	1 834		8.66	10.38
	F	2 035		9.58	9.44
	Both	3 869			
Biology	M	2 303		16.92	17.3
	F	3 350		18.01	16.13
	Both	5 653			
Total in Grade 12	M				
	F				
	Both				

* Percentages not available.

Table 5 - Enrolment of Grade 12 British Columbia Students Taking Senior Secondary Science Subjects

Subject		No.	%
Physics	M	4 857	38.0
	F	2 324	17.2
	Both	7 181	27.3
Chemistry	M	5 326	41.6
	F	4 789	35.4
	Both	10 115	38.4
Biology	M	5 808	45.4
	F	7 713	57.0
	Both	13 521	51.4
Total	M	12 790	
	F	13 538	
	Both	26 328	

Table 6 - Enrolment and Pass Rate of Grade 13 Ontario Students in Selected Science and Mathematics Subjects by Sex, 1979

Subject		Enrolment		Passing	
		No.	%	No.	%
Physics	M	12 592	31.2	11 425	90.7
	F	4 557	11.3	4 314	94.7
	Both	17 149	21.3	15 739	91.8
Chemistry	M	13 216	32.8	12 236	92.6
	F	8 954	22.2	8 555	95.5
	Both	22 170	27.5	20 791	93.8
Biology	M	10 521	26.1	9 590	91.2
	F	13 814	34.2	13 057	94.5
	Both	24 335	30.2	22 647	93.1
Pure Mathematics	M	40 342	100.0	36 639	90.8
	F	25 623	63.5	24 337	95.0
	Both	65 965	81.8		
*Total in Grade 13	M	40 342			
	F	40 342			
	Both	80 684			

* In the absence of data on total enrolment, we have substituted the largest enrolment of one sex in one subject (males in pure mathematics).

Table 7 - Total Canadian Female Undergraduate Enrolment in Selected Science Subjects, 1978-79

Place	Science			Medicine			Engineering		
	Total No.	%	No. Female	Total No.	%	No. Female	Total No.	%	No. Female
NFLD	1 159	46	534	235	34.6	81	428	7.5	32
PEI	209	37.7	79	-	-		73	2.7	2
NS	3 041	39.2	1 191	378	28.6	108	1 175	5.3	62
NB	1 486	43.5	679	-	-		1 595	8.3	133
PQ	8 032	38.2	3 068	3 331	39.2	1 306	8 742	8.1	708
ONT	17 206	39	6 706	3 120	30.0	935	16 943	9.3	1 572
MAN	2 628	34.2	900	726	27.3	198	1 218	5.2	63
SASK	1 882	34.9	657	381	35.7	136	1 082	4	43
ALTA	4 201	36.7	1 541	688	29	200	2 907	6.4	187
BC	4 356	31.9	1 391	683	27.1	185	1 886	8.8	166
CAN	44 200	37.8	16 714	9 541	33.0	3 149	36 049	8.2	2 968

Table 8 - Undergraduate Enrolment of Women by Field, Fall 1978

Field	Total Enrolment	Women	
		No.	%
Agriculture and Natural Resources	127 605	38 753	30
Biological Sciences	252 777	115 038	46
Engineering	451 160	49 742	11
Physical Sciences	123 986	32 720	26
All fields	8 698 694	4 375 715	50

Table 9 - Bachelor's and Master's Students, Fall 1976; Percentage of Women in Science Programs *

	Bachelor's program	Master's program
Biology	40%	26%
Chemistry	29%	17%
Mathematics	26%	26%
Geology	18%	-
Physics	15%	-

* These are statistics for women students enrolled in a program of studies, and not statistics for graduates. In 1977, the UQAM (Université du Québec à Montréal) offered no doctoral program in these disciplines.

Source: Work of the GIERF (Groupe interdisciplinaire pour l'enseignement et la recherche sur la condition des femmes de l'Université du Québec à Montréal) "La situation des femmes à l'Université du Québec à Montréal", Report 1978.

Table 10 - Percentage of Women Students in Science Programs at the Bachelor's and Master's Levels From 1969 to 1977*

1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76
16%	23%	24%	24%	23%	24%	29%

* These are statistics for women students enrolled in a program of studies, and not statistics for graduates. In 1977, the UQAM offered no doctoral programs in these studies.

Source: Ibid.

III. Sex Differences in Intellectual Ability

Based on a Presentation by
Dr. Meredith M. Kimball
Simon Fraser University
British Columbia

The data presented by Joan Scott make it clear that a great many girls are not studying physical science and mathematics at school, and they stand to lose out in the adult world as a result. The underlying reasons for this situation must be examined if the problem is to be attacked at its root. Because the situation exists for girls rather than boys, a considerable amount of time and energy has gone into the study of sex-related differences in intellectual ability.

Psychologists have frequently reported sex differences in test scores on verbal, mathematical, and visual-spatial tasks. There is considerable disagreement, however, concerning the size and relative importance of these sex differences and their origins. While some researchers claim that intrinsic biological factors such as brain structure, hormones, and genetic inheritance determine our intellectual abilities, others argue that different environmental conditions for young girls and boys lead to differences in the level to which their potential abilities are developed.

The exact origin of any sex differences in ability might be unimportant were it not for the tendency of educators, governments, and the public in general to accept the absence of girls from science and mathematics as "natural," suggesting that "nature" is somehow responsible for this lack of interest and achievement, and that we should not interfere. In more scientific terms, the suggestion is that girls are not able to "do" science well because of biologically determined inferior mathematical and spatial-visual abilities, and that efforts to improve their participation are futile and misdirected. We see this point of view reflected in comments such as that made by a Newsweek journalist in an article on sex differences in mathematical ability "... if they [the sex differences] are genetic, we must learn to accept them."[1,2]

In the light of such comments it must be pointed out that the nature and size of the effect that genetic and biological factors have on an individual's abilities and behaviour depend on the environment within which those factors are being expressed. A child who inherits a predisposition towards excellent muscular coordination may be weak and poorly coordinated if she is prevented from participating in physical activity. In the same way, a girl may inherit a tendency towards excellent mathematical and spatial-visual abilities, but if the opportunity to develop them is not available, she may seem to be weak in these areas. At the other end of the scale, it has become increasingly clear that the performance of mentally handicapped children and adults can be significantly improved when the appropriate educational programs are undertaken. If girls, in fact, inherit a tendency towards poor mathematical and spatial-visual abilities, which prevents them from becoming interested in science and achieving in this field, then we should be developing programs to enhance these abilities.

Therefore the main reason for studying the origin of sex differences in intellectual ability should be to obtain information of potential use in the design of programs to increase the participation of girls in science by improving their mathematical and spatial skills. It must be emphasized that there are many girls who have excellent visual-spatial and mathematical skills as well as many boys who are not talented in these areas. This information and the programs designed to help girls should be equally beneficial for boys having difficulties in these areas.

Evidence of Sex Differences in Ability

Popular reports about sex differences in ability directed at teachers, parents and the general public are often misleading. Headlines are sensationalized to attract attention, and articles often leave the impression that there are vast differences between girls' and boys' abilities to do mathematics or to accomplish spatial tasks. Readers are commonly led to believe that male and female brains function in totally different ways, and to assume that all boys are better at these tasks than all girls. Dr. Kimball pointed out, in her critique of the literature on the biological basis of sex differences, that,

> "in practical terms, all reported sex differences in ability are very small. Large numbers of children or adults are tested, and the difference between the population means is statistically significant. There is always a large area of overlap in the two distributions however, and the proportion of the variance accounted for by sex is very small.
>
> For all reported sex differences in ability, there are a few studies which find no differences and an occasional one in which the differences are reversed."

These difficulties may indicate that undefined environmental variables are affecting the development or measurement of abilities differently in different places or studies.

Janet Hyde has reanalyzed data from the reports that were used to conclude that certain sex differences in ability were "well established."[3,4] She points out that the term "well established" is often taken to mean "large" (rather than consistent). Because these conclusions are widely reported in introductory psychology texts this misinterpretation may lead counselors and other adults to dissuade girls from certain careers. Hyde's analysis shows that gender accounts for less than 5.0 per cent of the population variance in all of these studies. There is a small significant difference between the mean value for male and female populations (less than one-half of one standard deviation). These data tell us nothing about the origins of such differences. Hyde also discusses the problems of sampling involved in these studies. For a variety of reasons much of the data are based on tests of American undergraduate university students and cannot be considered a random sample of the overall population.

Dr. Kimball outlined the three areas in which significant sex differences in ability have been reported.

"1) Visual-Spatial Ability

Spatial ability has been defined as 'the ability to visually manipulate images without the aid of verbal mediation.'[5] The most common tests used to measure this ability are:

a) The Embedded Figures Test - subjects attempt to find a hidden figure as fast as possible.

b) The Block Design Test - subtest of the WAIS (Wechsler Adult Intelligence Scale) and WISC (Wechsler Intelligence Scale for Children). The subject is shown a red and white geometric design and is asked to reconstruct it from red and white blocks.

c) The Folding Blocks Test - the subject is shown a two-dimensional drawing of an unfolded form and asked to choose a three-dimensional form that would result from folding the 2-D form into the third dimension.

"The tests are timed to minimize the use of verbal mediation and faster times are given higher scores. Small sex differences in favour of males have consistently been found. The differences may begin to appear in early adolescence or may not show up until as late as sixteen years.[6] Within a study, differences may be found in some schools but not others, or at some ages but not others.[7]

"2) Mathematical Ability

In mathematical ability tests boys and girls do equally well up to early adolescence, when boys begin to outperform girls. The number of math courses taken by each student must be carefully controlled when testing adolescents for whom math courses are no longer compulsory. The male-female differences in mathematical ability are much smaller when this variable is controlled.[8] A recent study suggests that the sex difference in mathematical ability in grade seven and eight students may be large among the most mathematically talented students.[9] Although this study does control the number of courses taken in school, the authors use the scores the students achieve on the Scholastic Aptitude Test (SAT), a

> test which has traditionally been considered as a test of achievement rather than of ability."

This particular study was designed to identify students with outstanding mathematical ability. It was reasoned that students at the grade seven and eight level who can solve the SAT-M (Scholastic Achievement Test - Math) problems are likely to be mathematically talented, since at this level they have not been formally taught the mathematical concepts. In 1979 the number of boys who had scores above 600 was 3.5 times the number of girls. The authors conclude that a difference of this magnitude must reflect superior male mathematical ability, which is "probably the expression of both endogenous and exogenous variables." The conclusion should not be viewed with concern by those who are interested in the potential of girls to achieve in science. The SAT-M tests were administered to a group of students in the US previously identified by a standardized achievement test as being in the top 3.0 per cent of all students in mathematical reasoning ability.[10] In 1979 approximately 2.0 per cent of these students scored over 600; this included 3.2 per cent of the boys in the group and 0.9 per cent of the girls. In view of the fact that the sample being tested represent the top 3.0 per cent of the population, only approximately 0.06 per cent of the total population scored above 600. The study therefore examined a population of students at the upper end of the distribution curves where the number of boys would be expected to be much larger than the number of girls, if there is any difference in the mean scores of the two populations at all. The sex difference in the SAT-M scores is not larger among this group than among students of average ability.[11]

Perhaps the most important figure to consider in the context of this study is that 43 per cent of the top 3.0 per cent of students (in mathematical achievement) were girls. There are thus many girls in the population with superior mathematical ability who will have no difficulty achieving in scientific fields on this basis.

> "3) Verbal Ability
> On the average, females have higher scores than males on a wide range of verbal tests including verbal fluency, verbal reasoning, and vocabulary. One study concluded that girls begin to excel verbally at about ten or eleven years of age, and continue to do so throughout adulthood.[12] More recent data suggest that the differences begin to emerge much earlier.[13] Boys are much more likely than girls to develop a variety of verbally related disorders, including speech and reading problems."[14]

Boys also exhibit much higher rates of learning disorders and behaviour problems, such as hyperactivity, and are thus much more likely to receive professional attention at an early stage in the educational system than are girls. Cassidy examined sex bias in the referral rate of children who had been evaluated on the Conners Teachers Rating Scale, a behaviour rating inventory designed to identify children with learning and behaviour disorders.[15] Among the children identified as having problems in these areas, boys were twice as likely as girls to have been referred for help at some point in their school history. For children without specific problems in these areas, boys were three times as likely as girls to have been referred for special help or evaluation. This may reflect the importance of verbal abilities in the acquisition of reading and writing skills, which are taught in the early primary grades. Difficulties with these abilities are likely to be noticed and treated while other less obvious problems may go unnoticed.

Biological Explanations for Sex Differences in Ability

At least three different theories have been proposed to explain how biological factors may determine sex differences in ability. Genetic inheritance of a recessive gene on the X chromosome has been suggested as a mechanism that determines high potential mathematical ability and good visual-spatial abilities. Sex differences in spatial skills and verbal fluency have also been attributed to the influence of hormones on brain structure and function, and to a different degree of specialization of function of the two hemispheres of the cerebral cortex. The first theory is:

"1) The X-Linked Hypothesis
This theory hypothesizes that a recessive gene for high math potential or visual-spatial ability is carried on the X chromosome. Females have two X chromosomes (one from the mother and one from the father) while males have an X and a Y (the X from their mother, and the Y from their father). Because the gene for high ability is hypothesized to be recessive, the female must inherit two X chromosomes with the gene on it while the male needs to inherit only one X chromosome with the gene in order to have high potential ability.

"The chance of a female inheriting two X chromosomes is the square of the probability of a male inheriting one; thus many more males than females should show high ability. The distribution of ability for the two sexes should be different.

"According to this hypothesis there should be no relationship between fathers ability and sons' ability since the son does not receive an X chromosome from his father. The highest degree of relationship should be seen in the mother-son and father-daughter relationships. The son receives as his only X chromosome one of the mother"s two X chromosomes. The daughter always receives her father's only X chromosome, but also receives one of her mother's two X chromosomes.

"These two predictions of the X-linked theory have been tested with regard to the inheritance of potential mathematical ability. Stafford, using the Mental Arithmetic test, calculated intrafamilial correlations.[16] The only correlation that fit the theory was the father-son correlation which was 0.08, that is, close to zero. A later study found a significant father-son correlation (0.31) on the Wechsler Arithmetic subtest which is inconsistent with the theory.[17]

"Two tests of the X-linked hypothesis which look at differential distribution of male-female scores have not found evidence to support the hypothesis.[18] In both studies the proportion of women who had high scores was much larger than would have been predicted by the theory. In conclusion, the X-linked theory for inherited math ability has received very little support. This mechanism has also been suggested to explain the sex difference in spatial-visual ability.

> "While early studies reported intrafamilial correlations that fit those predicted by the X-linked hypothesis, four recent studies find correlations that do not fit the theory.[19] While Bock and Kolakowski and Stafford also report a bimodal distribution of scores for spatial ability...that is male scores and female scores are best described by two different distributions...Sherman and Fennema did not."[20]

The evidence for the X-linked hypothesis appears to be conflicting and inconclusive at this stage. Further doubt was cast on this theory during the discussion when Dr. Sheinin pointed out there is evidence to document the fact that in females, one of the X chromosomes very quickly becomes silent in all its functions. One would otherwise expect to find twice as many of the dominant X-linked properties in women, and this is not the case. In fact, with one silent X chromosome, the proportion of men and women expressing a high potential ability will be closer to equal than if both were active. Dr. Sheinin also pointed out that sex determinants are actually multifactorial; thus this attempt to attribute differences in achievement to sex-linked genetic factors is invalid.

The practice of approaching mathematical ability as a single, possibly genetically determined characteristic might bear further examination and discussion. The characteristic which is measured as mathematical ability would seem to be a composite of a number of different traits, any one or none of which might have a genetic component. The obviously graded abilities generally observed in the population argue in favour of a strong environmental influence on the development of potential ability. There is little or no evidence to support the notion that mathematical ability is a single all-or-nothing kind of characteristic which an individual either inherits (and then develops) or does not inherit.

> "2) The Role of Hormones in the Development of Abilities
>
> A role for hormones in the development of cognitive sex differences was suggested by Broverman.[21] Two different and supposedly opposite cognitive styles were defined:

> 1. The Automatization Style - This style involves superior performance on well-practised overlearned tasks that require a minimum of conscious effort to perform. Tasks which are said to be automatized include walking, writing, talking, reading, and verbal fluency. There is disagreement with this arbitrary definition of automatized tasks particularly with respect to reading.[22]
>
> 2. The Cognitive Restructuring Style - This style requires the inhibition of automatic responses to familiar stimuli and a preference for new responses to less obvious stimuli.

> "Broverman's theory hypothesizes that the following relationships exist:
>
> - females do better on automatized tasks while males do better on cognitive restructuring tasks. In fact, the evidence suggests that males do better on visual-spatial restructuring tasks, while females excel at verbal restructuring tasks such as anagrams;
> - these two cognitive styles are negatively correlated within individuals. Those who are good at one style are poor at the other;
> - gonadal hormones (estrogen, testosterone and progesterone) facilitate performance on automatized tasks;
> - estrogen is a more potent facilitator than testosterone;
> - hormones regulate an enzyme that controls the level of neurotransmitter in the sympathetic nervous system."

The evidence cited to support these suggestions is once again contradictory and inconclusive. Studies may be found that support the notion that testosterone concentration is related to cognitive ability in males, but this tells us nothing about sex differences, about the relative strength of estrogen and testosterone, or the effect of estrogen on female cognitive functioning.

> "It can be shown that levels of bound testosterone are positively related to performance of males on automatized tasks. The more testosterone present the better the male does on simple repetitive tasks. There appears, however, to be no relationship between the regular monthly fluctuations in estrogen levels in women and performance on automatized tasks.

> "Petersen assumed that gonadal hormone levels would be reflected in the degree of development of secondary sex characteristics.[23] Working with this assumption she found that high testosterone levels were related to better verbal fluency and poorer visual-spatial performance as predicted by the theory. For females, the results were less clear. While there was a negative relationship at age eighteen between performance on the spatial task and secondary sex characteristics, there was no relationship between physical characteristics and verbal fluency where Broverman would have predicted a positive one. Thus Petersen's results partially support the Broverman theory. The cause and effect relationship between body build and spatial ability was not established."

None of this evidence could be considered sufficient to establish a cause-effect relationship between gonadal hormones and cognitive abilities. Just as having black hair may be correlated with, but not caused by living in the Arctic, a cause-effect relationship could not be assumed even if the evidence for a correlation were more consistent.

> "3) The Brain Lateralization Theory
>
> This theory rests on the observation that the two hemispheres of the brain are to some extent specialized for different cognitive functions, the left for verbal tasks, the right hemisphere for non-verbal spatial functions. Evidence for the differential functioning of the two hemispheres comes from a number of sources. Sensory input from the right half of the body goes first to the left side of the brain, while that from the left side of the body goes first to the right side of the brain. In studies of selective attention, stimuli may be presented so that they are received first by either the right or left hemisphere. If stimuli are more accurately recognized when presented to one hemisphere than the other, then lateralization (specialization of that hemisphere relative to the other) is assumed to exist."

There is also evidence from patients with brain damage to one hemisphere that some functions are more drastically and permanently affected by injury to the left (or right) hemisphere than by injury to the other hemisphere.[24]

> "There is general agreement that the two hemispheres are undifferentiated at birth and that lateralization or specialization

> occurs during development. However, there is considerable disagreement as to when lateralization is complete. Some authors argue that lateralization is complete by the age of five while others assume it is not complete until adolesence."[25]

Two different theories are proposed to explain how differences in brain lateralization may be related to sex differences in abilities.

> "One theory assumes that superior function results from more bilateral representation of a task and thus of less lateralization.[26] The theory proposes that left cerebral dominance for verbal material is established earlier in girls than in boys. This results in less bilateral representation of spatial function and leads to poorer spatial-visual performance in girls.
>
> "Levy, on the other hand, believes that more lateralization should result in better spatial skills. She suggested that females have more bilateral representation of verbal skills than males and this interferes with spatial functioning in women.[27] The theory was later revised (1974) to suggest that bilateralization of verbal functions leads to superior verbal performance.[28] Thus Buffery and Gray propose that bilateral representation results in better spatial ability, while Levy proposes that bilateral representation of function results in inferior spatial ability. None of these assumptions and contradictions is particularly critical however, as there is no direct evidence to support any of them.[29] There is some evidence that females more than males use the left hemisphere for spatial tasks; that is, they employ verbal mediation strategies to solve spatial problems.[30] This may or may not represent greater or lesser lateralization of the spatial function. It is also possible that the spatial function is represented in both hemispheres to a greater degree in females than in males, but that is not a necessary assumption. With similar brain organization, females may simply develop a preference for a left brain verbal approach to the solution of spatial problems.[31]
>
> "There is some evidence to suggest that late-maturing children develop better spatial skills than early-maturing children.[32] This study might be of particular interest in view of the fact that girls, on average, mature slightly earlier than boys. However, Waber did not actually find sex differences in spatial abilities, which suggests that maturation age might be a more relevant variable than sex. Furthermore, Petersen was unable to replicate Waber's findings.[33]
>
> "In conclusion, the lateralization process which is itself poorly understood cannot account for sex differences in spatial or verbal ability."

In view of the lack of supporting evidence for any of the proposed biological explanations of sex differences in ability, one is led to believe that the influence of environmental factors on the development of ability should be examined. None of these theories provides reliable information that could be used in the design of a remedial educational strategy. While the evidence suggests that girls may be better at learning and solving problems in a verbal medium than in a visual medium, many boys fall into this category as well. It would seem that the presentation of mathematical and scientific material in a verbal manner might suit many girls and boys. The sex differences in ability are too small to be used as the key factor in selecting an educational strategy.

From a practical perspective the most significant observation may be that when the number of math courses studied by boys and girls is the same, the sex difference in measured "ability" in the mathematical field is minimized. While this observation suggests investigators were looking at achievement rather than ability, it would support the suggestion that girls should be required to take math throughout high school.

It was suggested in the discussion that there should be remedial or special training programs to develop mathematical and spatial skills like those used to improve reading skills. Work done at the Université du Québec à Trois Rivières shows that physical education has a very positive effect on academic performance, especially for girls. The skills which are developed and practised in playing sports, such as throwing a ball to a specific point, catching, positioning the body to be in the right place at the right time to receive a pass or hit a ball, may be very important to the development of spatial-visual and mathematical abilities.

Dr. Kimball summarized her impressions of the research on the biological origin of sex differences in intellectual ability in the following statement:

"A disproportionate amount of energy has been spent examining biological explanations that have very little or at best mixed evidence to support them. Most of the literature suggests that the observed differences are very small, and the overlap of the population distribution is large. We have been asking the wrong questions for too long. It is time to stop debating how large the sex differences are, if they exist at all, or where they come from.

"We must focus on the important question: Why is it that the difference in participation of men and women in scientific fields is so large, when sex differences in intellectual abilities are so small?"

IV. Science and the Environment of Young Girls

Based on a Presentation by
Dr. Linda Fischer
EHL Research and Evaluation Group
Toronto, Ontario

Once again, we return to the question posed in Chapter III: Why do so few girls study science? The evidence discussed there makes it seem unlikely that any inherent deficiency in female abilities deprives them of the potential for achievement. Hoyenga and Hoyenga have suggested developmental experiences and socialization of men and women determine the degree to which "readiness to learn" is encouraged and expressed.[1] Environmental factors, which either fail to develop, or discourage the development of potential ability, may influence girls not to study science. In the Soviet Union 70 per cent of doctors and 30 per cent of engineers are women, indicating many women in that country are encouraged to develop their scientific potential.[2]

Socialization could affect science involvement by two quite different routes. The learning and practice of science may depend on, or be facilitated by, a particular combination of mental abilities and character traits. The social roles imposed on a growing child may either discourage or foster activities which contribute to the development of these features. In this context, it is important to identify abilities and traits which actually contribute to science achievement.

In other situations, an imaginary scientist may be more influential than a real one. The child's image of a scientist, regardless of its accuracy, may appear compatible or at odds with her image of the person she wants to become. Socialization may affect either the real abilities required for the practice of science, or the child's interest in being a "scientist." Most children and adults appear to believe that becoming a scientist involves the adoption of a whole, particular lifestyle rather than simply training to do a job.[3] Scientists are thought to be more than normally meticulous, dedicated, intelligent, logical, impersonal, ambitious, and very masculine. Their work may be regarded as exciting and productive, or as boring, repetitive, and generally useless or even destructive. The most consistent features of the scientist stereotype are intelligence and masculinity.

Studies of successful scientists suggest that real scientists, whether as school children, university students, or adults, have in fact tended to be independent, self-confident, somewhat unsociable people with a strong nonverbal intelligence bias.[4] While some combination of these traits may be conducive to the development of an interest and ability in scientific fields, it is also possible that they are associated with exceptional achievement in many fields. An average scientist or engineer may exhibit a different set of personality characteristics, or similar traits to a lesser degree. Mahoney and Eiduson studied working scientists and found their most consistent set of characteristics included the abilities to be intensely involved and committed to a point of view, the capacity to make intuitive leaps, and the courage to take risks.[5] The successful practice of science requires a great deal more imagination and creativity than is reflected in the usual stereotype.[6]

At the workshop, Dr. Linda Fischer examined the impact of socialization on the science interest and activities of young girls between the ages of 6 and 12. She reported that:

> "Characteristics such as intelligence, strength, balance, etc. are not the exclusive domain of either boys or girls from 6 to 12 years of age.[7] The one irrefutable gender difference that does apply to the age group is that gender roles are different for males and females. Expectations about behaviour are different for girls and boys and the differences in expectation increase the older the group is."

In North America, as in all societies, there is a general concept of masculinity and femininity and of the particular behavioural traits that characterize them. These concepts form the basis of the sex-role stereotypes of our society and most of our social institutions reinforce and encourage behaviour which fits the appropriate stereotype. Attributes of the stereotype may vary depending on the social class, education, geographical location, family structure, and historical era in which the individual lives. As Dr. Fischer noted, the definitions of masculinity and feminity are hardly written in stone.

North American society generally tends to socialize males to become "providers" and females to become "care givers." Behavioural traits such as independence, assertiveness, objectivity, dominance, competitiveness, liking for science and math, ambition, decisiveness, etc. were all rated as masculine by subjects in one study.[8] Feminine behavioural traits, called "warmth-expressive" included tact, gentleness, talkativeness, quietness, neatness, interest in appearance, awareness of feelings, security orientation, and religiousness.

It is significant that "interest in science and math" was rated as a masculine character trait. The typical science-related character traits described before, such as independence, self confidence, objectivity, and rationality are also part of masculine "competency." Femininity, by contrast, involves being emotional, gentle, nonassertive and "good."[9] These characteristics are not the ones noted in successful scientists, and would not seem conducive to interest or achievement in this area.

These stereotypes of male and female behaviour are conveyed and reinforced in many ways by parental expectation and behaviour, peer pressure, television, literature, teachers and other social agents. Studies suggest that adults may respond differently to males and females even as newborn infants, generally smiling and verbalizing more to female infants, and having more physical contact with male babies.[10] It is difficult to determine if these behaviour differences originate with the parent or result from a difference in the responsiveness of the male and female babies to different stimuli. In either case, parental behaviour is likely to create or exaggerate a difference in the responsive tendencies of the babies.

> "However, all girls are not equally aware of the extent of the female stereotype. All girls are not as equally talented verbally and lacking in mathematical and spatial skills as sex difference reporting would lead us to believe, and many girls have escaped the stereotyping net, so the paths must be there. Our job is to widen them."

Dr. Fischer described a classification system or typology of girls based on their knowledge and acceptance of gender roles. This typology may be useful in assessing the potential response of individual girls to influences that may affect their interest and abilities in science and technology.

> "In one group we include those who, because of proclivity or socialization, tend toward predominantly "feminine" behaviour patterns, with an emphasis on "girls" games, personal appearance, and seeming to be "good." At the other end are those who tend toward "masculine" games, dress and interests...we call them "tomboys." Without being able to prove it, I would say that each of these categories of prepubescent girls included large numbers who understood stereotypes and had chosen to adopt one or the other set of behaviour patterns. Others in these two groups have been successfully socialized to certain patterns, which happen to be stereotyped, without realizing the behaviours are associated with one or the other sex. This includes the girl who is one of the boys because she has no one else with whom to play.
>
> We could summarize these two categories as follows:
>
> Feminine stereotyped girls:
> a) role consciously adopted
> b) role unconsciously adopted
>
> Masculine stereotyped girls:
> a) role consciously adopted
> b) role unconsciously adopted
>
> A third type of girl includes those who are relatively unaware of the stereotype and/or exhibit androgynous behaviour.[11] They move from all girl, to all boy, to mixed play groups, and engage in a

> variety of games. In certain situations they may be loners or associate primarily with adults. If tested, they would have fewer associations of characteristics with one sex only."

Androgynous people are defined as those who exhibit high scores on both masculinity and femininity scales.[12] These individuals have been found to be less conforming than either masculine or feminine people, more independent than the highly feminine subjects, and more nurturing than the highly masculine subjects of either gender. Allgeier found that androgynous women placed more importance on education and competence for themselves than feminine sex-typed women.[13] They were also more achievement oriented, wanted smaller families, had higher self-esteem, and were sick less often.

Maccoby concluded that analytic thinking, creativity, high general intelligence and high spatial-visual ability are all associated with cross-sex-type personality.[14] Masculinity and feminity were measured independently so that it was possible to have a high score on both scales. The high-ability boys tended to score slightly higher on the feminity scale and slightly lower on the masculinity scale than their lower-ability peers. The high-ability girls seemed to score high on both scales. These results do not suggest that the individuals were not interested in, or attractive to the opposite sex, but that they exhibit a wider range of less sex-stereotyped interests.

The strength of the stereotyping influence varies with the age of the person as well.

> "Some people have concluded that knowledge of stereotypes increases with age, and that knowledge of male stereotypes precedes that of female stereotypes.[15] They looked, however, at widely spaced intervals. We looked at every grade from kindergarten to grade five and used nonreactive tests in which the students were unaware that sex roles were being examined. Stereotypes of male occupations were strongest at the beginning of grades one and two, depending on occupation. They were less strong in kindergarten and after grade two."

Sex typing seems to be strongest, or most salient, to the adolescent.[16] Those girls who have adopted feminine stereotypes are experiencing their impact at the same time that they are making course choices which will affect their careers. If science is viewed as a male occupation conflicting with the feminine role, feminine sex-typed girls are unlikely to select these courses.

The effect of environmental factors on any individual will clearly depend upon the extent to which they have adopted the masculine or feminine stereotype, their age, and general stage of development. The effects are likely to be greatest on those who have adopted the most extreme stereotypes, and relatively less important to the (less conforming, more independent) androgynous individuals. The possible effects of environmental factors on strongly stereotyped girls is discussed. Less sex-typed girls may respond in similar but less pronounced ways, and, to the extent that they adopt some feminine characteristics, boys may also be affected.

The Effect of Stereotyping on Development

The feminine stereotype places a heavy emphasis on "goodness" and whether by nature or nurture, girls seem to be more aware of and responsive to feelings in both themselves and others than boys are.[17] Therefore it is relatively easy for parents and teachers to use approval and disapproval to control their behaviour. This technique shifts the source of personal satisfaction from task completion to external adult approval and may foster dependency and lack of self-confidence.[18]

> "Children who are successful in school generally get a healthy dose of 'positive strokes' from the teacher. Some will turn off their reward-getting behaviour because school is 'sissy' and those who do well are 'browners'."

This observation may reflect the influence of peer pressure from less able school mates.

> "Others, mostly girls but also some boys, will continue to strive for those rewards because they feel so good. The continued supply of those strokes can completely satisfy some childrens' needs and can, in fact, create an appetite for such a reward rate to continue. I call this approval addiction."

These children thus learn to rely on external sources for their feelings of competence.

> "It has been shown such needs are prevalent in women and that they affect their career progress.[19] Women have been shown to interpret lack of approval as disapproval...because they do not adjust to the fact that approval schedules diminish with age. Those who do not get addicted may have lower self-esteem, but they are less vulnerable to outside reward."

The desire to win approval may also result in a radical alteration in a child's approach to learning. A study by Silberman found that students who are anxious to receive good grades and teacher approval will hide their academic weaknesses and avoid areas of intellectual challenge.[20] Because girls receive approval for neatness, conformity, and good behavior they tend to adopt a very passive approach to learning. Previously successful patterns of behaviour are repeated in preference to the risky, more challenging business of attempting new solutions to more difficult problems.[21] Thus it seems girls tend to become less independent and self-confident, and are less likely to become involved in scientific areas, particularly if these areas are perceived to be both difficult and masculine.

There are clearly a great many environmental factors which have an impact on the desire of any individual to achieve and learn in the area of science. A common sense approach would suggest that the student who finds science interesting, who has been encouraged to explore and feel confident with the material, and who perceives scientific endeavour to be compatible with their other life expectations, will be motivated to study these subjects. Dr. Fischer then discussed the motivation to learn:

> "To the extent that science and technology are defined as male domains, some but not all, girls between 6 and 12 years of age might have difficulty being motivated to learn.
>
> "Many children, however, have no concept of these fields at the age of six. Many more would not have made such an identification although they might make it for part of these fields. Other girls who recognize them as male might then think them appropriate for themselves. There may be a few girls who define science and technology as inappropriate, but as they would very likely be the girls most motivated to achieve in school their minds can be changed. Considering that many basic concepts need not be identifiable as "science" one can imagine the girls being interested just because it is part of school."

However, older children and adults do seem to see ability in science and math as masculine traits.[22] This image may result in part from the predominance of men in science careers in both teaching and industry, and the suggestion is often made that providing role models of females who are interested and involved in science might increase the number of girls studying science. A young child, however, may be more inclined to emulate a girl who is only slightly older and who is interested and involved in scientific activities.

> "The role models should be as close in age as possible. For older girls, models of successful women scientists may illustrate visible career paths. For girls who are experiencing the pull of the domestic role, examples of happy husbands of high achievers might be in order. I'm thinking as early as grade five - before the conflict is stong."

The degree of social reinforcement (approval) offered to the student by the teacher may be more important than the sex of the teacher.[23] A male teacher who actively approves of and supports female students who achieve in science may be more effective in promoting the involvement of girls in science than a female teacher who does not. In fact, if girls tend to look for male approval to confirm their sexual identity at this age then it is probably important that they see scientific achievement being actively encouraged by both men and women.

> "Parent and teacher attitudes are also of critical importance. Torrance reported improved performance at, and enjoyment of creative scientific tasks of elementary school girls in one year.[24] The only intervention was to talk to the parents and teachers and attempt to convince them that girls needed these skills to be competent people. In the second testing, girls were as creative about the scientific use of objects as boys, but boys were evaluated as making more valuable contributions by both boys and girls."

This encouragement may be more important to girls than to boys because of their tendency to rely on adult approval for their self-concept.

The tendency for girls in single-sex schools to study physics, chemistry, and mathematics more often than do coeducated girls was noted by Dr. Sheinin in her opening address, and has been discussed by Ormerod.[25] Ormerod suggests that in coeducational schools the changes at puberty strongly affect subject choice, which may be used as a means of asserting gender identity. Physics and mathematics are strongly preferred and selected by boys; entering these classes therefore puts the girls into a predominantly male area where they must compete directly with the boys on an intellectual, academic level. Current social standards appear to encourage intellectual achievement by both sexes, but continue in fact to support the notion that boys are, and should be, smarter and stronger than girls. The more able girls may avoid situations where high academic achievement leads to awkward personal relationships with boys, especially between the age of 12 and 14 when sex-typing is strong and quite rigid. This conflict, which occurs at the time that science became an optional course, does not occur in single-sex schools. There is less pressure on girls to use subject choice to express gender identity or to avoid competing with boys.

There is also evidence that parents and teachers may inadvertently reinforce the idea that science is a male subject. In the panel discussion, Sharon Haggerty noted that girls are frequently subjected to teasing by male teachers and boys, and to comments that play on their role as girls. Personal appearance and behaviour are more often recognized than achievement, and some girls may avoid studying subjects with predominantly male enrolment and male teachers because they feel uncomfortable with this kind of attention. Another panelist, Dr. Heidi Kass, mentioned that student science teachers are often surprised to discover they have addressed most of their questions and comments to the boys in a practice teaching lesson. Girls in such classes may feel peripheral and uninvolved.

Dr. Fischer stressed that young girls, in elementary school and before, should acquire a basic body of scientific knowledge and develop an attitude of exploration. Studies have found that independent children have less protective mothers than passive children and that they also have higher visual-spatial scores.[26] Overly protected boys, and boys whose fathers were absent during their early childhood, tend to have high verbal scores relative to their mathematical scores, as do girls. These results suggest that the development of specific science-related abilities can be affected by child-rearing practices.

> "Kelly considers it important that girls who do not have an interest in ideas and concepts defined as male will miss out on many out-of-school experiences relevant to building a body of knowledge pertaining to science and technology.[27] Her concern leads us to the question of opportunity structure for having positive experiences with science and technology. She feels that some boys are motivated to learn, and, because they are boys, the opportunity structure is conducive to their having such experiences."

A child making paper airplanes may learn a great deal about air currents, angle, pressure and weight. Learning to cast a fish hook into just the right spot, or to catch an outfield fly may go a long way towards producing a nonverbal, intuitive understanding of distance, space, and direction.

Dr. Fischer pointed out the number of such experiences varies for boys as well as girls. Not all boys will have the relevant early experiences. They form an important step in knowledge building for both boys and girls and activities designed to help develop these concepts should be built into school programs for all children.

> "Boys often get a head start in science outside of school. A feedback loop is set up in which their initial interest is fed by school science and their growth in knowledge and interest is ahead of those with no initial interest. The increase in the lead of boys over girls from ages 10 to 14 is used as support for this. Sex differences in scientific achievement are reduced when girls have taken as many science courses as boys, if those courses are physics and chemistry.
>
> "Early experience of science is most likely to benefit high-ability girls who are comfortable with male-identified activities or who do not stereotype science strongly. The feedback loop will give them the most advantage. Others will follow their lead to a certain extent depending on the nature of the science experiences. Certain girls will benefit greatly by early science experiences that put them in the highest group of students in science interest and knowledge at an early age. If we wish to improve the long-term prospects for girls in science, it will be important to find ways of redefining science as neutral rather than masculine, which will put it into the acceptable range of even more girls. This can be done in the presentation and labeling of the knowledge and activities, as well as the people who are concerned with it.
>
> "The problems of combining career and family should be explicitly addressed, and clear models of women who are successful at both career and marriage should be provided. If these models include attractive men who respect their achieving wives, there may be a very positive spin-off for boys as well.
>
> "For quite awhile yet women in nontraditional careers are going to see themselves as different and will need to be stronger than the average. Girls who have learned to evaluate their own work and to derive satisfaction from the results in preference to relying strictly on adult approval will be better equipped to be independent. This may require that we diminish the quantity of positive reinforcement, especially when it is not sincere and prevents the child from testing his or her competency against some firm standard. At the same time one would introduce many possibilities for self-evaluation in all subject areas.
>
> "While seeming contradictory, it appears necessary to introduce positive reinforcement for nonstereotyped behaviours for both boys and girls. This means girls will benefit greatly from a recognition of success in science- or technology-based activities."

Dr. Fischer went on to endorse Kelly, who stated there was a need for research design incorporating some of the aforementioned ideas into elementary schools.[28] She continued:

> "We must not stop with one attempt and one evaluation. There is much to be learned and there will be useful feedback which will guide changes in the program. But, at the same time, recognition must be given to the varieties of types of girls and the different effects of certain changes on them. Then, given the number of forces that pressure women between puberty and adulthood, a longitudinal study is in order."

V. Role Models, Career Expectations, and Counseling

Based on a Presentation by
Dr. Dormer Ellis
Ontario Institute for Studies in Education
Toronto

Dr. Fischer underlined the importance of providing girls with models of women who are successful both socially and in their careers. These models are especially important in the early high school years, as girls begin to form an image of the life they would like to lead and the kind of people they would like to become. For the vast majority, marriage and family will form a central piece of this picture and, if careers are thought to be unnecessary or to conflict with these goals, they will not be given serious consideration. Girls must be aware of the importance of planning a future in the work force and of the relevance of mathematics and science courses to those plans. In order to have a running chance at a career in any field, every student must begin with the facts about working, planning careers, and handling domestic responsibilities.

Dr. Dormer Ellis is an experienced professional engineer and educational researcher who has had a long-term interest in the scarcity of women in science. She has studied the relationship between role models, career aspirations, the involvement of girls in science, and the part that parents and counselors can and do play in this interaction. She described for the workshop how her curiosity about these problems was raised:

> "Five hundred and fifty professional engineers and scientists gathered in Cracow, Poland in September 1975 for a week of formal meetings, informal discussions and tours of industries. There

> were civil, electrical, mechanical, chemical and metallurgical engineers as well as research scientists, science teachers and university professors. The Polish delegates, four hundred strong, came from all the industrial centres of their country. Among the hundred and fifty foreign delegates were representatives of thirty-two countries. They ranged in age from the early twenties to the late sixties. And all were *women*! They had come to Poland to attend the Fourth International Conference of Women Engineers and Scientists.[1]
>
> "In Canada, there are many professional engineers, and almost all of them are men. It might seem that this is only right and proper, being a natural consequence of some innate weakness of the female brain that prevents women from grasping mathematical concepts and technical principles. However, when one attends international conferences of women engineers and scientists, held in France, Italy, Poland and England, and realizes how much higher the participation rate of women in scientific and technical occupations is in other parts of the world, it becomes difficult to believe that only *Canadian* women suffer from this mental affliction.
>
> "The notion that this situation does not have to be permanent is much enhanced by observation of events taking place south of our border. One effect of the affirmative action program of the United States government has been the dramatic increase in the number of women in traditionally masculine occupations. Literally thousands of young women engineers are now employed in both private and public sectors.[2]
>
> "Progress is being made in Canada also, although it is only fairly recently that the pace has accelerated. Consider, for example, the enrolment of women students in the engineering faculty at the University of Toronto. When I was a first-year student in the early 1940s, it was possible to count on one hand all the women engineering students in all four undergraduate years. Thirty years later, there were 56 women students, and just two years after that, the number had almost doubled to 108. Female enrolment continues to rise year by year, just as it does in other engineering faculties across the country. However, women students are still a small minority. It is too early for us to have statistical information about the lifetime career patterns of Canadian women who were sufficiently unconventional to enrol in engineering studies at university."

Dr. Ellis has been involved in a long-term study of the career patterns of male engineers between 1955 and 1976. She mentioned being struck by the great diversity of occupations in which these men were engaged at age 40.

> "Some were still doing strictly technical work, while others had moved into management positions or business administration. Some were in engineering sales, secondary school mathematics and science teaching, or editing technical journals. Others were teaching engineering technology at the postsecondary level or carrying out research. The work actually being done by these engineering graduates twenty years after they began their engineering studies did not require any great amount of physical strength or the ability to grow a beard. In short, their interesting and relatively well-paid work could equally have been undertaken by women."[3]

She has recently instituted a similar longitudinal study of women engineering students; it was not until the mid 1970s that there was a sufficiently large number of women enrolled in engineering to make the results of such an investigation statistically valid. One hundred and sixty-three women who were in first year engineering in Ontario Universities in 1976 were studied. Information from this study suggests that role models may not be as important to the career decisions of this particular group of students as is often assumed.[4]

> "Although writers on vocational guidance discuss the effectiveness of role models on the career decisions of young people, apparently role models are not absolutely essential - at least not for the small minority of secondary-school girls who are willing to go against social customs and enrol in engineering. Before making the decision to begin university studies in some branch of engineering, only 2 of the 163 research subjects had ever met a women engineer. Three more could recall the name of a woman engineer, not necessarily a Canadian, about whom they had read. None of the others had anyone who could be termed a same-sex role model for the profession they were preparing to enter. Many of them did not even know whether or not there were any women engineers practising in this country. However, it is rather interesting to note that almost half the research subjects had a female relative, neighbour or friend of the family who was successful in a predominantly masculine field. It might be an aunt who was a lawyer, a neighbour in accounting or a cousin studying medicine."

This interesting observation deserves more attention and possibly some research. None of the role models mentioned were engineers, but they seemed to have had a general influence on the overall level of aspiration of these girls by making female achievement in a "male" field appear desirable and rewarding. It must be remembered that this particular sample of women is a very small and, by virtue of the fact that they were enrolled in engineering, not typical. As outlined in Chapter IV, some girls are less affected by stereotypes than others and some perceive masculine fields as appropriate for themselves. Dr. Ellis pointed out that role models and parental encouragement (or discouragement) may be more important in the decisions of the large number of girls who do not choose nontraditional careers.

> "In response to questionnaire items about who had attempted to dissuade them when they decided to enrol in engineering, these first-year students named their mothers more often than any other person. Students who indicated their mothers had not been comfortable with their choice of university program usually explained that this was due to fears about its influence on their marriage possibilities. Some mothers thought engineering studies would be too demanding, leaving little time for social life. Others warned their engineering-bound daughters that eligible young men would not be attracted to them if they made it obvious that they were smart. Obviously, the research subjects had ignored their mothers' advice, but one can only speculate about how many other gifted young women are dissuaded, by similar arguments, from preparing for careers in technical and scientific occupations."

Many factors affect a girl's career aspirations. Her personal image of the role of women in society forms a backdrop that colours all her career decisions and expectations. The support she receives from the adults in her life will have a definitive effect on whether she achieves her goals. Dr. Ellis reported some interesting experiences mentioned by the female engineering students in her study.

> "Although there were a few exceptions, the vast majority of the first-year women engineering students reported that their male relatives, particularly their fathers, were very supportive of their decision to study engineering. However, some fathers did express concern that prejudice against employing women in responsible positions might make it difficult to find employment after graduation. Fortunately, these fathers' fears have been disproved by the great succes of the 1980 graduating class in finding suitable employment.

> "It was not only at home, but also in the secondary schools, that men were more supportive than women of the research subjects' choice of university course. However, they got very little encouragement to study engineering from teachers, principals or counselors of either sex. This finding is rather surprising. While these young women were growing up, a great deal of public attention was focused on women's changing roles in society. The Royal Commission on the Status of Women in Canada, with its extensive media coverage, drew attention to the social consequences of women's traditionally inferior position in the world of work. International Women's Year gave considerable impetus to attempts to improve women's opportunities in all aspects of life. In particular, Canada's 'Why Not?' campaign sought to widen the career horizons of young girls by publicizing nontraditional occupations for women. It became illegal for newspapers to have their employment advertisements classified under the headings, 'Help Wanted-MALE' and 'Help Wanted-FEMALE' and the sex of the applicant must not be specified by the employer. There is no doubt that all these events have had some effect on the school system. For example, sex-role stereotyping has been greatly reduced in school readers, and textbooks in all subject areas are being rewritten to avoid sexist language. Also, publicly supported schools are now expected to have all their courses open to both boys and girls.
>
> "Nevertheless, school systems are essentially conservative and traditional customs and beliefs cannot be eliminated overnight. In theory, guidance counselors in the secondary schools encourage all students to make the best use of their abilities. But in practice? Of the 163 research subjects, only 2 felt they had been given any real encouragement from a guidance teacher to enrol in engineering. The others said their school counselors were not enthusiastic about their very unconventional choice and had suggested more traditional alternatives."

It is clear that the unarticulated assumptions that parents, counselors, and teachers make about the position of females in science must be re-examined. Our discomfort with the idea of a girl in engineering or a woman in nuclear physics is reflected in our failure to encourage girls to consider the nontraditional occupations, as well as in more outright attempts to discourage girls from pursuing these careers. Many girls will lower their aspirations when confronted by the explicit or implicit beliefs of adults.

A very important distinction should be made at this point between career aspirations and career expectations. A study by Avis Glaze (a researcher with the Metropolitan Toronto School Board) of a group of girls in southern Ontario high schools illustrated this point.

> "The Glaze study documented the gap between these girls' career aspirations and expectations. Their aspirations were more likely to be nontraditional than were their expectations. For example, a girl might aspire to be a lawyer but expect to be a typist in a law office; she might aspire to be a pharmacist but expect to be a checkout clerk in a drug store; she might aspire to be a doctor but expect to be a nurse."[5]

Another situation in which a large difference between career aspirations and expectations exists was revealed in a study, funded by the Ontario Ministry of Education, of the characteristics and needs of 2000 Franco-Ontarian students.

> "The researchers found that the occupational expectations of the students were low and not in keeping with either their abilities or the level of education they planned to achieve. This was especially true in the case of the female students. Although many of them stated that they planned to complete high school and even undertake postsecondary studies, none expected to enter an occupation requiring more than a very elementary knowledge of science. No girl said she planned to become a biologist or a high school physics teacher or a geologist or a chemical technologist... . The challenge of providing career counseling for young girls should not be underestimated."[6]

Girls seem to have a great deal of wrong information about the participation of women in the work force and about the importance of education in their lives. This is an area which urgently requires the attention of counselors, and re-education should be extended to parents as well. Results from the Glaze study highlight this need.

> "The girls were studied using a variety of questionnaires and inventories to ascertain their knowledge of facts concerning women's participation in the work force and to identify their own career aspirations and expectations. When tested on their knowledge of facts (based on information from Statistics Canada), these 17- to 19-year old girls revealed a great deal of misinformation and acceptance of myths concerning, for example, the

> average number of years that a Canadian women spends in remunerative employment, the proportion of married women working outside the home, and the likelihood of a woman university graduate marrying.[7] It is hardly surprising that their subject choices and plans for the future are often unrealistic and not in their own best interests."

The extent of the misconceptions held by the girls in this study was truly shocking, and forces us to consider once again where these ideas come from and how they can best be changed. Despite dramatic changes in the opportunities for women in the world today and despite the publicity these changes have received, girls in high school still view career women as eccentric or, at least, unusual. The majority of the girls in the Glaze study expected to spend a few years working, then marry and retire from the work force when their children were born. This view is especially alarming in the light of Canadian statistics showing 8 out of 10 women will work for wages for at least 30 years.[8] Many girls believed the statement that 40 per cent of women university graduates never marry, and that there is a higher divorce rate among career women than among housewives. Neither of these statements is true.[9]

For a vast number of women today, work is an economic necessity. They cannot afford the luxury of choice. The statistics quoted in the introduction concerning the impact of female unemployment on poverty in Canada speak for themselves, and their message must be clearly conveyed to girls while they are still in school. The changes that are presently occurring in the workplace will eliminate, or at least drastically curtail, employment in many traditionally female job areas. Banking machines that handle all standard money transactions, pay bills and make loans without benefit of a teller are already in use in some Canadian banks. Computer memory storage facilities eliminate filing clerks as well as cabinets, and electronic switching devices do the work of many telephone operators.[10] Many of the girls who do not plan careers and do not study the appropriate subjects will find themselves relegated to low-paying and low-status jobs, well below their ability. A basic understanding of mathematics, electronics and physics is essential in many of the skilled technical occupations that are developing. The role of school counselors in making sure that girls are aware of these facts about the workplace cannot be overemphasized.

A variety of programs for developing greater career awareness and widening the range of career interests among grade nine girls were tested by Dr. Liz Sayer when she was a doctoral student at OISE (Ontario Institute for Studies in Education). One of the programs, which made use of role models, brought out some important features that must be considered in the design of such programs.

> "Audio-visual methods were used to present to the students examples of women who were successful in their occupations. The manner in which these women integrated their working lives and their family responsibilities was also included. Some of the role models were engaged in traditionally feminine occupations and others were in occupations considered rather unusual for women. All the programs examined by Sayer, including the one based on role models, did serve to increase the number of career choices in which the grade nine girls showed an interest. The fact that school programs do not exist in a vacuum but are just one part of the daily lives of students is illustrated by an incident reported by Sayer. When listing career interests prior to the introduction of the career awareness programs in the school, only one girl mentioned a certain career choice. However, in a follow-up study done some weeks later, this particular career choice rated very high indeed among the grade nine girls in the study. It was not a career on which emphasis had been placed in the school program. It was that of cruise director. During the intervening weeks, a television show with one female lead, a cruise director on "The Love Boat," had become very popular with the students. Sayer comments that this is an excellent example of the effect of role modeling as the girls were repeatedly exposed to a very attractive young woman, in a romantic setting, having a prestigious occupation with, apparently, no particular academic requirements."

We should take careful note of some of the determining features of this situation. The role model was very attractive to girls of this age. Her work was exciting and she was clearly attractive to and accepted by other people. The girls were repeatedly exposed to this image over a period of weeks, and thus the example was continuously reinforced.

> "Perhaps the time has come when we can make effective use of role models in the career development programs of school guidance departments. In the past, this activity was severely restricted in the case of scientific and technical occupations by the very scarcity of female role models. However, the situation is improving and may have reached the point where we can expect a snowball effect."

Dr. Ellis cited The First Canadian Convention of Women Engineers held in May 1980 in Toronto as a fine example. Here, Canadian women engineers discussed vital day-to-day concerns such as environmental problems, petroleum engineering, electronics and computer applications. All the speakers could be held up as very positive role models. Such gatherings of women scientists are one way that young women could be made aware that women not only can, but do, prepare themselves for and enjoy interesting and rewarding careers in science. She concluded with the hope that everything possible would be done to highlight positive role models for schoolgirls. They will then be encouraged to include science in every year of their secondary school programs, and so be ready and anxious to make the best possible use of their abilities, becoming even better role models for the next generation.

VI. Intervention Techniques Assessment and Recommendations

Based on a paper by
Dr. Lynda J. Erickson
University of British Columbia

It seems the forces that steer girls away from science begin early in life and continue throughout the school years. Different elements of the problem assume varying degrees of importance at different ages, beginning with the lack of a wide range of experiences in the pre- and elementary school years. Girls tend to avoid scientific activities because they do not excel in them. This tendency is reinforced by teaching and child-rearing methods which encourage girls to work for adult approval rather than personal satisfaction. Gradually, scientific and technical activities begin to acquire a masculine mystique because girls, who avoid taking part in them, become more and more unfamiliar and uncomfortable with the material. By the time that high school course choices are being made, many girls feel incompetent with the material and uncomfortable in the social classroom situation. Sexual stereotypes are rigid at this age. Media images of women, the obvious absence of women in science teaching and other science careers, and misconceptions about the need to develop long-term career plans have a dramatic impact on girls' career aspirations and course choices.

There can be no single, simple solution to a problem whose origins are so complex and diverse. Action in many areas at the same time is required, and research is needed to define the combination of steps that will be most effective. A solution will also depend on fundamental changes in society, as outlined by Dr. Sheinin.

A variety of possible approaches were discussed in a recent report to the government of British Columbia on gender and math/science education in that province.[1] Dr. Lynda Erickson outlined the recommendations of the report and reviewed some remedial programs developed in the United States to increase the participation of girls in mathematics, and to a lesser extent, in science. The review was not intended to be comprehensive; its purpose was to develop some understanding of the nature and scope of the available programs.

> "Virtually all the programs that have been developed to address the problem of female underachievement in science and mathematics (where the most varied and extensive work has been done) were initiated in the United States. Canada it seems, is far behind in this regard.
>
> "The activities developed in the science area fall into three categories:
>
> a) career workshops and other materials addressed to students;
> b) workshops for teachers of science and school career counselors;
> c) curriculum projects, or classes for girls in science content areas.
>
> "Career programs for students were the first technique explicitly addressed to the problem of females and science. As a result, these programs have proliferated, perhaps because they are the least expensive, least complex, and least controversial sort of activity to initiate.* Their general objective is to encourage female interest in science-based occupations. Audiences range from elementary school pupils to college students and the programs range from the provision of media materials to the establishment of residency career workshops.
>
> "Some of the media programs are quite elaborate. MIT (Massachusetts Institute of Technology) has produced a half-hour film on women in engineering that looks at the experience of women engineers from the perspective of female engineering students, faculty members, and professionals. But the limitations of such

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* See the publication of the Association of American Colleges Project on the Status and Education of Women, Recruiting Women for Traditionally "Male" Careers: Programs and Resources for Getting Women Into the Men's World. See also the bibliography in Kaseberg and Downie, 1980.

> programs should be apparent. The absence of personal contact means that individual student differences in situation and personality cannot be discussed. It seems unlikely that this one minute source of media communication can in any significant way alter the stereotype of science as a male domain."

The impact of media images of women in science can be considered on a broader basis. Dr. Ellis mentioned the portrayal of an attractive female, actively enjoying an exciting career, had a dramatic (if temporary) impact on the career aspirations of a group of grade nine girls. The media influence seemed stronger than that of any of the regular career awareness materials. Books, movies, and television programs frequently portray women in science as serious, dowdy, rather unsociable, unfeminine people. These images are not attractive to teenage girls, and they reinforce the notion that science is an area for masculine people. Presenting women in science as attractive people who lead rewarding and exciting family and social lives might have a very positive effect on girls' attitudes to science as a career.

> "Counseling workshops, in contrast to media projects, seem to have greater potential for impact on career aspirations. They do involve personal interaction and can accommodate individual differences. The popularity of one set of workshops, the 'Expanding Your Horizons' conferences developed by the EQUALS program in California, has been established.[2] Although primarily designed to encourage females' interest and confidence in mathematics, these conferences include an important workshop element on careers in science. Suggestions concerning the design of workshop panels and activities are now available from this program for distribution, and would be helpful for teachers who wish to undertake such a project.[3] But research on the impact of the career aspects of the EQUALS program has yet to be published, so the effectiveness of such workshops is difficult to judge."

The importance of encouragement from parents, teachers, and school counselors was stressed by every contributor. Dr. Sheinin spoke of the impact of the home and the streets; Dr. Ellis mentioned the fears that mothers express about the influence of science careers on marriage prospects; and Dr. Fischer noted the experiments of Torrance on the effects on girls of parental awareness of the importance of science.[4]

This aspect of the problem has not been adequately addressed by intervention programs.

> "In our examination of intervention programs, we found only one project on workshops for teachers. This project, again undertaken as part of the EQUALS program, attempts to develop teachers' and counselors' awareness of the sex-stereotyping of mathematics and science and the limitations girls face in their career options if they do not study mathematics. A number of model workshops for inservice training have been developed for distribution as a result of the popularity of their initial workshops with educators in California. Participants who attended earlier workshops are now conducting their own inservice programs for other teachers.
>
> "One aspect of the one-day program that seemed to be a good technique for stimulating teachers' commitment to the workshop was the requirement that each participant undertake a small research program in advance of the session. Projects they suggested included:
>
> a) collection of data on enrolments of girls and boys in mathematics classes in their school;
> b) compiling data on their male and female students' projections concerning a typical day in their lives at age 30."

Parents and teachers must become more aware of the ways in which their own attitudes and behaviour may bias girls' attitudes to science. Similar projects could be designed to examine whether science teachers tend to interact more with the boys in their classes.

There have not been many attempts to provide remedial programs in science content or concept formation. The need for such programs has been discussed and was further emphasized by findings in the BC report.

> "Girls score below boys on achievement tests designed to assess learning in science, both in understanding and applying concepts. As early as grade four, sex-related differences are apparent, and by grade twelve, the percentage differences have increased.
>
> "Projects in this area should address the apparent disadvantage girls face with respect to their 'informal' learning of science. Since science teaching often builds on this informal knowledge boys seem to find science less difficult to understand than do

> girls. The potential benefit of special curriculum projects was indicated by one small classroom project. Kelly and Kelly found that boys better understood the concept of 'horizontality' than did girls.[5] These sex-related differences disappeared when experiences to improve understanding of this phenomenon were made available to both sexes."

Part of the program to change the masculine image of science involves making the content of science classes and texts more obviously relevant and interesting to girls. For instance, the examples used in physics problems could be drawn from the areas in which girls have everyday experience.

> "Packaging material in a more androgynous manner could make girls more comfortable with science, and contribute to their confidence in the subject. While some individual educators and textbook writers may be moving in this direction, a more formal coordinated program has not materialized."

Dr. Erickson pointed out these programs have not been adequately assessed, and that recommendations for action must be somewhat tentative. However, the need for action in certain areas is clear.

> "There is general agreement that sociocultural factors play the major role in fostering observed sex-related differences in achievement in science. These factors are widespread and pervasive. Effective techniques to counteract them must therefore be undertaken at a number of levels and with a number of different kinds of programs."

Girls who feel incompetent in science as a result of inadequate early experiences with scientific concepts are not likely to become interested in science careers as a result of career workshops or movies. On the other hand, girls who do not perceive science as an appropriate, interesting field for women are less likely to be interested in improving their understanding of scientific concepts than those who do.

The specific recommendations outlined by Dr. Erickson in the report to the BC government addressed four kinds of educational constituencies:

> 1. those responsible for science curriculum development and curriculum policies;
> 2. educational researchers;
> 3. those responsible for inservice and preservice teacher education; and
> 4. training and inservice personnel concerned with school counseling and school counselors.

Recommendations for curriculum policy centred on the need to provide sexism guidelines, and to develop materials emphasizing the relevance of science to human problems.

> "Sexism guidelines should not only prohibit the more obvious kinds of sexism, but should indicate less apparent kinds of bias, often overlooked, that are as great a problem. The absence of females in science texts, the omission of women scientists in historical discussions of science, and the use of examples of scientific phenomena drawn mainly from the world of boys' experience are subtle forms of bias which reinforce the view that science is a man's domain. These factors may make girls feel peripheral in science classes.
>
> "Curriculum materials which stress the relevance of science to human problems should be developed and disseminated. Science education research suggests that these materials may increase girls' interest in science as they may value social interests more than boys and are more attracted by careers involving social service. Prevailing views of science and scientists often neglect the contributions made by science and technology to the betterment of the human condition, and as a result, girls may see science as antithetical to their personal values. Attempts should be made to teach students about the ways in which science can be used to solve problems, and how scientific knowledge can help us to understand the implications of technology. Some attitudinal barriers may be eliminated in this way."

Dr. Erickson went on to recommend the development of programs and materials to upgrade girls' "informal" knowledge of science as well.

> "At the elementary school level, classroom activity centres and other classroom learning projects should be designed to improve

> girls' understanding of basic physical concepts. Learning activity centres could provide some of the experiences and observations which help children to form basic concepts relevant to science. Encouraging children to experiment and explore with materials in the centres can provide experience important to later understanding."

Dr. Sheinin pointed out in her opening remarks that girls in single-sex schools seem to succeed in science and mathematics much more frequently than girls in coeducational schools. This fact, also noted by Joan Scott, was addressed in the recommendations as well.

> "Another, perhaps more controversial recommendation suggested the development of experimental courses in the physical sciences for girls. Such courses would NOT be less rigorous with respect to the concepts, theories, and experiments covered. However the material would be presented in terms more relevant to girls, and teaching methods would be designed to encourage the interest and participation of female students. Enrolment in these classes should be limited to girls only in the beginning stages. Participants in experimental mathematics classes for females have suggested that girls may do better in experimental classes that are sex-segregated when the subject is considered to be a male domain. Teachers play an important role in such experimental classes. Their enthusiasm for the project, and for their subject area, should be very high. An understanding on the part of the teacher of the social processes which contribute to the problem of girls and science would be a further factor in the success of such classes."

It is clear that a great deal of educational research is needed to improve the data on which our assumptions and predictions are based. Four areas for research aimed at elucidating the factors which affect girls' interest in science and math courses were suggested.

> "First, a project that would identify high schools with unusually high enrolments of girls in physical science courses. Comparisons and contrasts would then be made with other high schools which are less successful in this regard. The objective of the study would be to determine the kind of school characteristics and policies which foster girls' interest in science. Such a study could then be the basis of further recommendations concerning effective ways to deal with the enrolment problem.

> "A second project would study the characteristics and experience of individual high school girls in the province who study noncompulsory physical science courses and who plan to enter nontraditional science programs in postsecondary institutions. This study could identify cognitive, affective, and experiential factors which contribute to high interest and enrolment.
>
> "A third study might attempt to identify the kind of common-sense science knowledge that boys have and girls lack at the elementary school level. This would be an important aid in developing curriculum materials to improve the informal science knowledge that girls seem to lack. Girls may develop negative attitudes toward science because they are at an initial disadvantage. Since positive attitudes appear to be related to doing well in a subject area and taking courses in it, boys' initial lead over girls is increased in later years. In order to arrest this process, girls should be provided with opportunities to learn many of the things that boys already know."

A fourth recommended project aims at assessing the effectiveness of certain experimental projects, on a small scale:

> "Specific intervention projects should be undertaken within a number of physical science classes. Researchers and science teachers could join forces to design and evaluate particular strategies and materials to overcome problems girls encounter. These would be small scale experimental courses and could be highly flexible, in addition to developing techniques and materials that could later be used on a larger scale."

The attitudes the classroom teachers hold towards girls in science are also very influential in fostering or discouraging girls' interest in studying science. This was addressed in recommendations for inservice training programs.

> "The programs should help teachers to examine their own expectations for girls and boys in science, and to develop an awareness of sociocultural factors which contribute to girls underachievement in this area. Issues of classroom management, student-teacher interactions and the presentation of science subject materials should be discussed and related to sex differences in achievement.
>
> "Inservice packages should also be designed to deal with resistance from some teachers to these programs; some time should be spent discussing the philosophical and practical objections

which are typically raised. Work done by Burton suggests that a number of stages of response often accompany attitudinal changes in this area.[6]

"The technique of asking teachers to do a research project on girls and science in their own school, prior to an inservice program, seems to be an effective method of increasing interest and commitment. It is important that teachers play a role in the development of ideas and strategies to promote girls' interest in physical science.

"Preservice units on girls and science should be developed for prospective teachers. At the elementary level teachers should be made aware of the importance of preschool experience to the development of science concepts and of the tendency for girls to be deficient in this regard. These units should provide examples of activities that can help girls acquire these basic concepts through classroom experiences.

"Units for secondary-school teachers should include an analysis of sex-role stereotyping and how science comes to be perceived as a male domain. Prospective teachers should be encouraged and assisted to develop curricular materials which present science concepts in ways relevant and understandable to girls as well as boys. The philosophical and practical objections that students may have toward these units on girls and science should be discussed, as in the inservice programs."

Career counselors play an important role in encouraging girls to continue to study science, and in increasing their awareness of the variety of science careers open to them. Dr. Erickson's recommendations suggested that inservice programs are needed for career counselors to increase their awareness of the problem and of their potential role in its solution.

Their purpose should be to help counselors:

a) examine their own expectations for boys' and girls' occupations;
b) understand the factors which contribute to the limited career perspectives that girls develop, and their tendency to avoid physical sciences;
c) consider ways of promoting girls' interest in nontraditional, science-related careers.

A final recommendation put forward suggested that career workshops for students should be developed. These should attempt to increase girls' knowledge and awareness of science-related careers and should provide them with an opportunity to observe and interact with women in science-related occupations.

> "These recommendations were designed to attack the problem on a number of different fronts, because we believe this would be the most successful way to approach what we view as mainly a socio-cultural problem. If too much investment is made at only one level, failure may mean that official efforts are discontinued. In addition, with this strategy, awareness of the problem should increase among educators and the public in general."

VII. Practical Perspectives

The conflict between theoretical ideas and practical realities is a well-known fact in the life of every teacher. As parents, doctors, artists and carpenters, we all feel qualified to tell classroom teachers how to do their jobs. Frequently, however, suggestions that appear so logical are simply not feasible in a classroom environment. The real work of changing the participation of girls in science will, in the end, fall on policy makers, teachers, guidance counselors, and educators of teachers. Representatives of these groups were invited to take part in a panel discussion about the practical framework within which the theoretical proposals must operate. Panel participants included Dr. Heidi Kass (a teacher educator and curriculum researcher at the University of Alberta), Sharon Haggerty (an experienced science teacher who is presently doing research on girls and science education at the University of British Columbia,) Mary Ruggiero (a graduate student in engineering at the University of Toronto), and Grace Parasuik (a consultant on women's issues in the Manitoba Department of Education).

We are concerned about three quite different levels of scientific involvement. The kind of science education required for each level must be clarified.

At one level we want to increase the participation of girls in science in order to improve the scientific literacy of women in general, because the ability to understand the general issues in science is a valuable life skill. What kind of science education is required to produce discriminating consumers and responsible citizens?

At another level, the scientific and technical skills of women must be improved because they are the tools of tomorrow's trades. What specific mathematical, scientific and technical information will women need to be prepared for a broad range of technical occupations?

And finally, on both an ideological and a practical level, we need to increase the number of professional women scientists. What kind of science education will attract more of the talented girls in our schools into these fields?

There was a strong feeling among panelists and participants that improvement in all these three areas depends on our ability to interest girls in science in early elementary school. Teachers of these early grades must display an active liking for and involvement in the ideas and activities of math and science. From a developmental point of view, grades six to nine seem to be crucial years for developing scientific interests and the curriculum should emphasize stimulating and practical science activities. During these years, when sex differences in science and mathematics achievement begin to emerge, science is often taught, unfortunately, by people who have an inadequate background for doing so, or who might prefer to move into high school teaching or administration.

A great deal can be done in early grades to foster basic conceptual development in science through language arts programs. Curriculum materials that reflect this interest are needed and these materials should also present a larger range of occupational roles for women. Grace Parasuik quoted one textbook study in which 370 roles for men and 80 roles for women were portrayed. There were no female archaeologists, engineers, or geologists (although there were two women astronauts and one inventor). The most consistent roles portrayed for women were mothers and grandmothers, teachers and librarians, authors, princesses, queens and witches.

Scientific literacy and general interest in science might be greatly improved if students were better able to see the usefulness of science in their daily lives. Teachers who treat physical science as though it were simply an accumulation of factual abstractions will dampen a child's interest in the subject early in school. The science curriculum needs to be revised so that more emphasis can be placed on the social, applied, historical and psychological contexts of science. Women should be involved in designing these programs and in preparing appropriate materials.

School counselors have an important part to play in urging girls to acquire scientific and technical skills in preparation for the changing job market. The content of the science courses these students are offered should be appropriate to their ability level and their career goals, and curriculum materials should stress the applications of the information. Dr. Kass re-emphasized the importance of teachers' attitudes in developing career aspirations. Adults who expect girls to achieve poorly in science convey this impression to their students, with the result that girls do not feel confident with scientific material. Poor performance becomes a self-fulfilling prophecy.

It has been suggested that long-range studies of average girls, like the kind carried out by Dr. Ellis with the female engineering students, might provide useful information about the variables which affect women's career choices and achievement patterns. Sharon Haggerty and others have noted that high achievement is often associated with attending an all-girls school, with being the oldest child in a small family, with identifying strongly with the father, and with having high-achieving female role models in the environment. More specific information about the factors that discourage girls from studying physics and mathematics is needed. The personal experiences described by Mary Ruggiero suggest that her excellent academic record in these subjects sustained her determination to study engineering in the face of a steady undercurrent of negativity on the part of adults. As Dr. Fischer pointed out, girls respond differently to these negative attitudes depending on their self-concept, and some are more easily discouraged by adult dispproval than others. Ms. Ruggiero also mentioned a number of situations in which girls are made to feel eccentric, or simply uncomfortable, by adults who deliberately draw attention to their presence in science classes. Thus the two factors that seem to be most strongly related to choosing a profession in science or engineering are academic achievement and adult attitude towards nontraditional career choices.

Efforts to interest girls in science must therefore begin early in elementary school, and teachers and parents should provide interesting scientific experiences which help girls to feel comfortable and confident in these activities. Science curricula and materials must stress the relevance and applications of the science content to everyday life. Career counseling to raise awareness of the need for girls to plan careers and to widen the range of career options is essential. Counselors, teachers, and parents must all re-examine the attitudes they display concerning the involvement of girls in science.

The fact that Dr. Erickson's recommendations are directed towards parents, teachers, curriculum developers and policy makers, reveals that we all help turn the wheel. The values, ideals, attitudes and expectations we convey to our children force the wheel around in its relentless cycle. We are the ones who must act to change its direction The future of Canadian girls in science depends on our willingness to try.

VIII. Closing Remarks

Louise Marcil-Lacoste
Université de Montréal

I have chosen, in these closing remarks, to reflect on the more striking and salient aspects of today's papers. In general, I suppose these reflections focus on Dr. Sheinin's question, "Who Turns the Wheel?" I came here today with the conviction there was a problem with the science education of women in Canada. However, many of the things which have been said suggest this problem has no one specific feature, no specific cause that calls for a specific solution. We face a paradox. Although we expect to find specific causes for, or solutions, to the problem of girls in science, the problem seems overwhelming precisely because it has no specificity. It stems from all sorts of factors which play a role in human life. My plea, therefore, is that we recognize the absolute necessity of adopting a pluralistic approach to this question. Indeed, one of the highlights of the day has been the recognition that the source of this problem cannot be pinpointed.

We are faced with multiple causes, calling, as Dr. Fischer mentioned, for more pluralistic, heuristic models than are usually used. Dr. Kimball's suggestion that we have been asking the wrong questions for too long is significant. It is always helpful to know where not to waste research time and it seems that too much attention has been devoted to asking how large the sex differences in intellectual ability are, if they exist at all, and where they come from, with rather negative results. The question we should be asking, to quote Dr. Kimball, is "Why is the difference in the participation of men and women in scientific fields so large, when the sex differences in intellectual abilities are so small?" It is my suggestion that the Council should focus continuing work on the problems raised by this last question.

My second remark concerns the presuppositions with which we address this problem. When considering why girls take fewer science courses in high school than boys, why they abandon math at an earlier grade level, or seldom study senior physics or math courses, we generally look for obstacles. Yet it could be that the origins of the problem lie more in what is absent from girls' education rather than what is present as a malignant cause.

I think a whole new kind of research is needed to support the policy statement which was read to us by the Honourable Lynn Verge. That statement expressed the need not only for equal access to science courses, but for affirmative action on the whole network of educational options.

Dr. Ellis has pointed out that because regulations in schools, universities and professional associations are the same for boys and girls, one is forced to consider the weight of other related factors, such as lifetime career patterns. We must assess the weight that dilemmas such as choosing to be a mother or to have a career carry in determining a girl's motivation to study science. The choice then is not whether one should become a professional in this or that scientific area, but whether to try to become both a professional and a mother. Because science is a very demanding activity, girls may hesitate to make this addition to an already heavy dilemma. Dr. Erickson mentioned that the impact of providing girl students with models of highly successful women in science (what I call the Madame Curie syndrome) is very limited. To what extent do the depressed aspirations of women in science result from the fact that they have to aim at being both Madame Curie and a super-mother? I may be more sensitive to this question because I am presently going through this experiment myself, and I can hear my baby crying for his night breastfeeding at this moment. I want to emphasize that while scientific careers are not impossible for women, the woman who chooses to be both a scientist and a mother requires more determination, more energy and more confidence than the one who chooses to be only a scientist.

As we study the situation of girls in science we can assess the relative importance of a diversity of factors. Among these the concrete impact of day-to-day exposure to all sorts of ridiculous little burdens should not be dismissed, though it may be of little theoretical significance. Girls entering science do not face the idealistic situation at which we are aiming. They face the real situation with its variable component of unglorified forms of sexism.

It would also be useful to dig deeper into attitudes. I was struck by Ms. Haggerty's comments on the fact that boys receive more encouragement and support for doing science than girls. I wonder whether day-to-day experience would confirm the so-called "approval addiction" that we have ascribed to girls. Could it be that girls attach more value to approval precisely because they are trying to do something which is outside the stereotype? Their apparent addiction may occur in inverse proportion to the approval they actually get.

My third comment has to do with the clash between what I will dub the common-sense view of the problem and the more scientific views presented here. The former, if I may say so, is that for biological reasons girls are not good at science and when they are, it is a matter of exception. From that point of view, some say this is the way it is and will be, and some say this is the way it is and should not be (though perhaps will be). However, when we look more closely we find that we don't have the data which could give us a precise picture of the problem. This paucity of statistics may be taken as proof that there is no problem, or in Joan Scott's words, as evidence that nobody cares about it. I suggest that we address the "nobody cares" problem, rather than the "no problem" problem.

In contrast to the common-sense view we find the data suggest some girls are good at science and those who are may be exceptional or they may be quite average. One is tempted to conclude the problem is not as serious as one imagined at first. At the very least, it may seem to result from some of the very features we deeply wanted in our school system: more freedom in option choice, more diversity in the teaching staff, more specialization in the teaching role.

However, the frailness of so many of the explanations of the relative absence of girls from science classes leads to the question, "Why are there so many situations in the domain of scientific achievement where women are treated and/or act as a token or minority group?" If children have a limited conscious awareness of career stereotypes, we must concern ourselves with the hidden sex roles in science, and as Ms. Parasuik noted, with the whole realm of parent and teacher attitudes. It may be that the female stereotype, while less precise than the male stereotype, is actually more forceful. We must not discard the problem of stereotyping because of the diffuseness, or nonspecificity of the stereotypes.

If I may be allowed to borrow from my own area of research I would like to cite an example. Recently a huge book on women in the 18th century was published. Its author, Paul Hoffman, has studied the account of the feminine nature given by physicians, scientists and philosophers throughout the 18th century.

The contradictory nature of the set of predicates used to describe women's nature is striking. Some claim that typically women are active, but others say that typically women are passive. Women are said to be typically inclined to inhabit an imaginary world, or on the contrary, inclined to be down-to-earth. Women are typically inclined to be abstract or typically inclined to be concrete, typically calm, and typically hysterical. They are typically inclined to stay in the middle, or they are typically inclined to go to extremes. They are typically inclined to work on details, to have the analytical outlook, or typically inclined to be very superficial and concerned with broad issues. Surprisingly, Hoffman does not conclude from all these materials that science is a poor basis for defining the feminine nature. Instead he asks, "Can anybody be freer than a woman who could be the bearer of so many features?" as if a woman could choose among the epithets rather than being forced into the most negative one.

Closer study of the sources reveals that in theories valuing activity, women are typically said to be passive, whereas in theories valuing passivity, women are said to be active. The diversity of the comments is no proof of an absence of a discrimination against women. The specific contribution of schooling to sexual stereotypes may be explained as part of the basis of pervasive sexism in society itself, which is explained as a result of sexist family education which is itself explained by the limits of human nature which, we are told, does not change rapidly. A great deal depends on the attitude we bring to the issue. We may find studies to support all sorts of attitudes but ultimately we must decide whether we study this problem with a view to contributing to its solution because we value equality, or whether we shall be willing, though perhaps unhappy, to stop our inquiries at the point where it seems that the problem is too complex, its magnitude too great, to have a solution. If we refuse the double bind confinement, if we refuse to act as if we should have one basic strategy, one main solution, one single target or scapegoat, then perhaps we will see that our problem is not without cause or solution.

If we can see the problem has multiple causes and multiple levels, we may find there are at least partial solutions. I am referring to what can be done at all levels through the programs and experiments suggested by Dr. Erickson and others on the panel. If the Science Council could help to create and support the will to do something, and to go beyond the too little, too late, too complex, too controversial syndrome, I dare to think our next workshop could focus on more concrete, workable steps in a good direction, and be more optimistic about the future of women in science.

APPENDICES

APPENDIX A

The Minister's Address

by

The Honourable Lynn Verge
Minister of Education
Newfoundland and Labrador
and
President
Council Of Ministers of Education, Canada

Before becoming involved in politics I practised law, and through my law practice I saw first hand the problems encountered by women in our society and culture. I spent many hours working on a voluntary basis in the women's movement and working at a grass-roots level to effect changes in family law and in the education system. I recognize the importance of the Science Council's decision both to study the extent to which school science education is failing to meet the needs and aspirations of Canadian girls and women and to seek ways to eliminate the shortcomings.

I can see change coming in two ways: first, as part of a global effort to change the nature and shape of the whole of society. But while we are waiting for this revolution to occur, there are more direct, specific affirmative actions which can be taken to improve the quality of science education for girls and women.

I think it is fair to proceed upon the assumption that girls and women experience difficulties in the sphere of science education that mirror those encountered by women in so many other domains of our Canadian society. Wherever women are questioning the viability of traditional attitudes or practices, wherever we are exploring the range of activities that challenge our capabilities as women, we find two social phenomena common to most of our living patterns and practices. The first is the underrepresentation or absence of women in decision-making processes at many levels of the education system: the political level, the senior official level in ministries and departments of education, the school-board level, and in the professional unions and associations of teachers. The second phenomenon is that outside the roles and occupations traditionally associated with women there are limited expectations of a woman's ability to achieve, and limited opportunities for a woman to exercise fully her talents and abilities. Anyone who is sensitive to the thinking and attitudes conceived through the women's movement can understand the negative effects these phenomena generate for women.

In our country, provincial governments have responsibility for education. This results in a variety of educational systems. The mutual concerns and interests of the ten individual departments of education are discussed jointly through the Council of Ministers of Education, Canada. Each province is a member, preserving its own autonomy but also working jointly with other members, on a consensus basis, on areas of shared concern. Together they approach the federal government, on an equal footing, to deliberate over issues of federal as well as provincial interest.

The ministries or departments of education have the responsibility to set policy directions in each province. The departments determine overall policies, set guidelines and determine curricula for use by school boards in schools and classrooms throughout each province.

There are other components of the educational system in each province, of course. There are the regional and local school boards and their professional administrators, there are the individual classroom teachers and their professional associations and unions; there are the university faculties of education or teacher training institutions; the parents' associations, and finally, in the case of the separate school system, or in Newfoundland, where there is a denominational education system, the churches have an important role to play.

I believe change won't be achieved within the various education systems unless each component of the system is affected.

Improvement can be initiated through enlightened leadership at the political level, in senior decision-making, or administrative positions. But it will not be truly effective unless it is supported at the grassroots level. I think it is more likely that change will occur when it originates at this grassroots level, through interest and pressure groups that work at and within all the various parts of the education system, within the political parties, within teacher's professional associations and unions, within school boards, and within the parent's associations.

The Organization for Economic Cooperation and Development (OECD) attempted to stimulate government awareness of the condition of women in education through its resources and a Committee on Social Needs. The OECD report was released at its meeting in November, 1979, and the OECD education committee agreed to consider the report's recommendations. Canadian participants in that discussion had been briefed by the provinces, whose education ministries had earlier reacted to the report's contents.

The report covered a broad range of subjects, including the consequences of the emerging role of women in the paid labour force; the effect of role prejudice on education and career choices for young girls; and the reinforcement of sexual stereotyping at home and in sex segregated classes. The report reviewed courses emphasizing traditional women's occupations such as nursing, and the continued predominance of young women in courses traditionally viewed as female at the secondary and postsecondary levels. In responding to the issues raised in the report, different provincial ministries offered a variety of potential solutions to the problems, and I would like to give some examples.

From Saskatchewan representatives came the suggestion that an alternative future can be presented to young men and women through the introduction of systematic affirmative action programs examining traditional life roles and nontraditional occupations. I am not fully familiar with the intentions or results of this recommendation.

Officials of the Ontario Ministry pointed out that traditional areas of employment for women are closing and that there is an urgent need to improve the access of young women to nontraditional academic and skills-training courses, including industrial arts.

The speed with which an education department can effect attitudinal change concerned representation from Nova Scotia. While stereotyping in textbooks can be reduced or removed, attitudes must change gradually, as this involves changing people as well as procedures and materials.

The whole exercise of producing and debating the OECD report is evidence of some positive response on the part of governments in the area of equal opportunity in education for males and females. I am somewhat skeptical however that these developments will be felt in the classroom for some time. There may be more productive avenues for effecting change in the other components of the education system. Recommendations concerning strategies for improvement have been prepared for my own department of education by a ministerial Advisory Committee on Women's Issues in Education, which was established in January of 1980. The committee, which comprises twelve people (mainly feminists) from different parts of the education system, has been working for more than a year. Its recommendations for a policy statement have been adopted by the Department of Education in Newfoundland. The recommendations are:

- males and females within the school system and in postsecondary institutions will have equal access to all courses and programs offered by the school;
- both sexes will be actively encouraged to take advantage of the full range of course offerings regardless of traditional stereotypes for roles and expectations;
- both sexes will receive adequate, unbiased guidance to encourage them to participate in courses which have been dominated by one sex in the past;
- girls and boys will have equal access to sensitive, informed and unbiased guidance services which will provide awareness, information and active encouragement to all

students. Opportunities for further education or training, career choices and possible employment areas should be explored;

- with respect to instructional issues, all students, at all levels of the educational system should have access to teachers of both sexes where this is feasible and practical;

- all curriculum instructional and enrichment materials utilized within provincial schools shall present a nonstereotyped and unbiased image of both sexes. Materials for children and young adults should emphasize the contribution and value of each individual within society regardless of sex. The materials that are used should promote the ideals of democracy, the self-worth of each person, and the goal of equality for all groups within the society. Those materials that deal with history, culture, science and society should present an unbiased position that recognizes the major contributions of women in these areas;

- with respect to hiring practices, all institutions, school boards and government departments concerned with education should provide equal opportunity and access for both sexes in their recruiting, hiring and promotion practices. Active encouragement and professional incentives should be provided to ensure an equitable distribution of the sexes in all levels of responsibility and decision making in education;

- full and equal participation of women with men in the employment of teachers and administrators, and in recruitment of policy makers at the school board, and at the legislative level.

These recommendations have not been translated into any noticeable improvements in our province. More important is the continuing work of the Advisory Committee in developing strategies for actually achieving these goals. In a draft report which will be finalized in the next six weeks, the committee proposes that the Education Department undertake the following:

1) to work jointly with agencies such as the teachers' professional associations and adult education administrators to develop leadership training courses focusing on the professional development of women teachers;

2) to initiate action leading to professional inservice on sex roles, and stereotyping within schools;

> 3) to develop teacher handbooks on bias and sexual stereotyping in curriculum materials, and train teachers to reduce bias and stereotyping in instructional materials;
>
> 4) to encourage the use of nonstereotyped career guidance material developed by the department through teacher inservice programs;
>
> 5) to ensure that all courses be coeducational with timetable flexibility so that students may pursue courses in which they are interested.

My understanding of this statement is that all courses should be made available to both boys and girls in our province where we have a denominational education system. Roman Catholic high schools in the larger population centres are separate for girls and boys. I was interested in hearing of the possible advantages to girls in separate girls' schools; however, we have noticed in my province that the course offerings in girls' schools are more restrictive. For example, in girls' schools, even those with very high enrolments relative to other schools, physics and honours math are not even offered.

The committee also recommends that recruitment procedures at the board level should encourage women to seek positions held by men.

These recommendations are founded upon studies of actions taken by other provinces to improve opportunities for women in education. Some of these provinces have pioneered work in the areas of eliminating sex-role stereotyping and producing positive employment directions. The Ontario Ministry has adopted policy statements regarding equal opportunity and sex-role stereotyping. In addition, the Ministry has organized conferences aimed at reducing stereotyping in learning materials, social roles and expectations for student achievement. A Vancouver school board has approved policies regarding discriminatory practices in schools, and on the subjects of equal opportunities in administrative and support roles, women's studies career guidance and stereotyping. Québec, which has encouraged the full and equal participation of women in so many areas, has implemented some of the programs and policy statements contained in the report of the Québec Status of Women Council called Québec Women: Equality and Independence. In Manitoba, the Education Department has made women's studies materials available throughout the schools. In conjunction with this effort, the Manitoba Teachers' Association has been active in providing inservice training for educators, and in emphasizing awareness of equal employment opportunities. They have worked with the Winnipeg Teachers' Association and the

Winnipeg School Division to implement an affirmative action plan for women superintendents.

The Saskatchewan Education Ministry has set up a special project to investigate ways of exposing secondary-school students to nontraditional career alternatives.

Since many agencies share responsibility for education, I think that a cooperative approach is necessary. I see a real opportunity for women who are science teachers to work within their own professional associations and unions. Science teachers should have the support of their peers in advising and pressuring school boards and provincial ministeries to provide more leadership and initiative. In my province, at the secondary level, 85 per cent of the science teachers are men; only 15 per cent are women. Teachers are going to need the support of men and of their peers throughout the teaching profession. They will need cooperation from career guidance counselors and assistance from the leaders of their professional associations to foster the objectives adopted by the Department of Education for the teaching profession and for school boards.

Teachers can make an even more direct and definitive impact on what students think through simple measures in their own classes. Science teachers can inspire students by activities such as having women scientists, or women in science-related occupations visit the classroom; and holding science fairs focusing on the importance of science in choosing careers or future educational and training courses.

I firmly believe that improvements in women's issues must be initiated at the grassroots level. The ideal situation combines this support with inspired or enlightened leadership at the political and administrative levels. These efforts could be coordinated with policy directions from the administrative levels of the education system.

The Canadian Education Association (CEA) focused on women's issues a few years ago, and in 1976 passed a resolution on women in education. I think it is useful to examine that resolution:

> "-Whereas experience since the publication in 1970 of the report of the Royal Commission on the Status of Women has only confirmed that Canadian society exhibits attitudes and structural patterns which work to the disadvantage of women in their education, in their careers, in their economic, social, and political lives, and generally in their full development as persons, with opportunities and responsibilities equal to those of their male fellow citizens, and has

further shown that these deeply ingrained biases will change only slowly and under persistent pressure,

"-Whereas many studies across Canada have demonstrated that instructional materials and methods used in schools often exhibit sex typing to the disadvantage of both male and female students and

"-Whereas the Canadian Education Association has benefited by presentations at its 1975 and 1976 conventions on the topics of sex discrimination and sex typing and should now state the Association's position on these important issues be it resolved that;

"a) that the CEA confirm its commitment to equality of opportunity for men and women in all aspects of Canadian life and more particularly in all conditions affecting education and employment, and confirm its opposition to any conditions which directly or indirectly restrict the full participation in Canadian life of any person on the basis of sex and

"b) that the CEA confirm its support for the efforts of trustees, teachers, and other confirmed persons to reduce sex typing in the instructional materials and methods used in Canadian schools,

"c) that the CEA support the use of education resources to counteract sex discrimination and sex typing where these currently exist, and to reduce the effects of sex discrimination and sex typing where they existed in the past, and

"d) that the Board of Directors make the Association's position on these issues known to educational and other bodies, and to the public in general by whatever means the Board considers appropriate and effective."

I think that is quite a good statement of ideals, appropriate for any organization concerned with full and equal educational opportunities for girls and women.

However, as I mentioned before, I think our efforts now have to be directed at practical strategies for achieving some of these goals. That will come through the lobbying and united efforts of feminists within the various components of educational systems in the provinces, and at the national level. We will also need to have people in key positions at the political level, with school boards, within teachers' professional associations and unions, and parents' organizations.

APPENDIX B - LIST OF PARTICIPANTS

Jacquelin Anderson
Family/Women's Studies Consultant
Ottawa Board of Education
Ottawa, Ontario

Doug Bannister
Senior and Continuing Education Branch
Ontario Ministry of Education
Toronto, Ontario

Dr. Shelley Beauchamp
Standards and Programs Division
Ontario Ministry of Labour
Toronto, Ontario

Karen Birchard
Specialist Reporter
CBC National Radio News
Toronto, Ontario

Meriel Bradford
Program Delivery
Ministry of State for Social Development
Ottawa, Ontario

Barbara Byrne
Manotick, Ontario

Maureen Carpenter
Ottawa, Ontario

Carol Collier
Status of Women Canada
Ottawa, Ontario

John Cornfield
Science Consultant
Ottawa Board of Education
Ottawa, Ontario

Dr. Marthe Demers
Faculté des sciences de l'education
Université de Montréal
Montréal, Québec

Alexis Deweil
Women's Programs Division
Secretary of State
Ottawa, Ontario

Dr. Gaalen Erickson
Faculty of Education
University of British Columbia
Vancouver, British Columbia

Nicole Ferguson
Association des enseignants de sciences
Moncton, New Brunswick

Theodora Foster
Interpares
Ottawa, Ontario

Dr. Margaret Gillett
Administration & Policy Studies in Education
McGill University
Montreal, Quebec

Sylvia Gold
Director of Professional Development Services
Canadian Teachers Federation
Ottawa, Ontario

Dr. Isabelle Lasvergnas-Grémy
Département de sociologie
Université du Québec à Montréal
Montréal, Québec

Teena Hendlemann
City-Wide Testing
Ottawa Board of Education
Ottawa, Ontario

Lynn Hindle
Counseling
George Vanier Secondary School
Willowdale, Ontario

Dr. James Jones
Sociology Department
State University of New York
Brockport, New York

Donna Kirby
Public Service Commission
Equal Opportunities for Women
Ottawa, Ontario

Mary Kyles
Canadian Federation of University Women
Ottawa, Ontario

Leslie Lewis
Ontario Manpower Commission
Toronto, Ontario

Alexander Liutec
Science Teachers Association of Quebec
St. Lambert, Quebec

Carolyn Malboef
Student
Immaculata High School
Ottawa, Ontario

Andrea McDonald
Student
Immaculata High School
Ottawa, Ontario

Heather Menzies
Canadian Research Institute on Public Policy
Ottawa, Ontario

Mel McLeod
Science Teachers Association of Ontario
Glebe Collegiate
Ottawa, Ontario

Linda Sue McKeever
Executive Assistant to the Minister
Ministry of Education
St. John's, Newfoundland

Marg Munroe
Science Writer
Ottawa Citizen
Ottawa, Ontario

Sister Patricia Mullins
Dean of Humanities and Sciences
Mount Saint Vincent University
Halifax, Nova Scotia

Jocelyne Picot
Canadian Medical Association
Ottawa, Ontario

Dr. Marion Porter
Department of Sociology
Carleton University
Ottawa, Ontario

Dr. Ercilia Quintin
Département de psychologie
Université du Québec à Trois Rivières
Trois Rivières, Québec

Lynn Quon
Reporter for Canadian Press
Ottawa, Ontario

Dr. Tom Russell
Faculty of Education
Queen's University
Kingston, Ontario

Rosaline Séguin
APAME
Shawinigan Sud, Québec

Susan Shalala
New Brunswick Advisory Council on the Status of Women
Moncton, New Brunswick

Dr. Soulange Simard-Savoie
Département de stomatologie
Faculté de médecine dentaire
Université de Montréal
Montréal, Québec

Valentina Slobodian
Professional Development
Ontario Teachers Federation
Toronto, Ontario

Bert Stahlke
Education Officer, Elementary Branch
Ontario Ministry of Education
Toronto, Ontario

Dr. Beth Van Fossen
State University of New York
Department of Sociology
Brockport, New York

Lois Webster
c/o Gordon Robertson Education Centre
Frobisher Bay, Northwest Territories

Maureen Woodrow
Social Sciences & Humanities Research Council
Ottawa, Ontario

Dr. Isobel Wright
Montreal Children's Hospital
Montreal, Quebec

Participants from Science Council

Isme Alam
Research Associate

Frances Bonney
Librarian

Margaret Dorning
General Editor

Paul Dufour
Research Associate

Janet Ferguson
Workshop Coordinator

Dr. Maurice L'Abbé
Executive Director

Dr. Louise Marcil-Lacosté
Science Education Committee Member
Département de philosophie
Université de Montréal

Judith Miller
Science Adviser

Graham Orpwood
Science Adviser and Project Officer
Science and Education Study

Dr. Beverley Robertson
Science Council Member
Department of Physics
University of Regina

Dr. H.R. Robertson
Chairman, Science Education Committee and
Science Council Member

Jean-Pascal Souque
Science Adviser

Jill Stainforth
Public Affairs Officer

APPENDIX C - CONTRIBUTORS TO WORKSHOP

Dr. Dormer Ellis
Ontario Institute for Studies in Education
Depts. of Adult Education/ Education and Measurement, Evaluation and Computer Applications
Toronto, Ontario

Dr. Lynda Erickson
Department of Political Science
University of British Columbia
Vancouver, British Columbia

Dr. Linda Fischer
Research Consultant
EHL Research Evaluation Group
Toronto, Ontario

Sharon Haggerty
Faculty of Education
University of British Columbia
Vancouver, British Columbia

Dr. Heidi Kass
Department of Secondary Education
University of Alberta
Edmonton, Alberta

Dr. Meredith Kimball
Psychology/Women's Studies
Simon Fraser University
Burnaby, British Columbia

Grace Parasuik
Curriculum Consultant
Department of Education
Winnipeg, Manitoba

Mary Ruggiero
Department of Metallurgy
University of Toronto
Toronto, Ontario

Joan Scott
Department of Biology
Memorial University, Junior Division
St. John's, Newfoundland

Dr. Rose Sheinin
Department of Microbiology and Parasitology
Toronto, Ontario

NOTES

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